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**REMEDIAL INVESTIGATION REPORT FOR
OPERABLE UNIT 1 VOLUME 5 APPENDICES D
AND E OCTOBER 1993**

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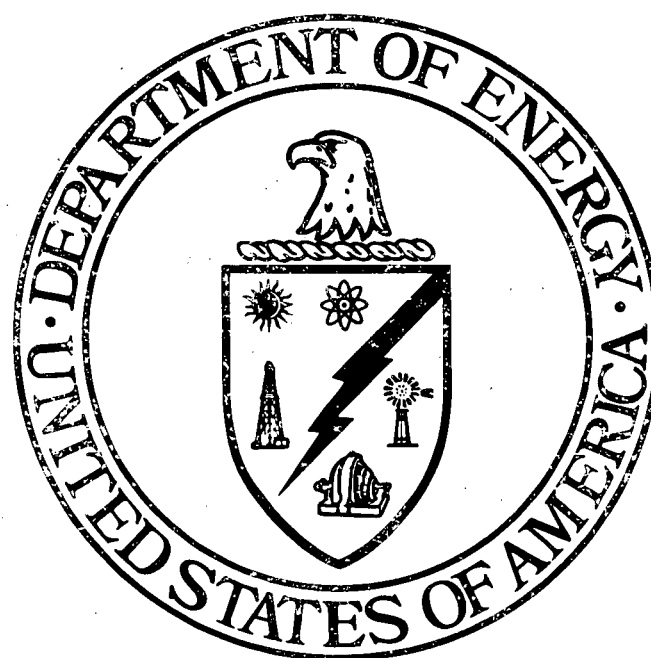
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REPORT**

REMEDIAL INVESTIGATION REPORT FOR OPERABLE UNIT 1

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

VOLUME 5
APPENDICES D and E



OCTOBER 1993

U.S. DEPARTMENT OF ENERGY
FERNALD FIELD OFFICE

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4787

**OUI RI APPENDIX D
TABLE OF CONTENTS**

	<u>Page</u>
D.1.0 Geochemical Analysis	D-1-1
D.1.1 Introduction	D-1-1
D.1.2 Site-Specific Data	D-1-1
D.1.3 Development of the Conceptual Model	D-1-2
D.1.4 Estimation of Leachate Concentrations	D-1-3
D.1.4.1 Methodology for Inorganics and Radionuclides	D-1-3
D.1.4.2 Methodology for Organic Compounds	D-1-7
D.1.4.3 Estimation of Inorganic and Radionuclide Concentrations	D-1-7
D.1.4.4 Estimation of Organic Leachate	D-1-8
D.1.4.5 Summary	D-1-8
D.1.5 Discussion of Results and Observed Data	D-1-9
D.1.5.1 Leachate A and B for Inorganics and Radionuclides	D-1-9
D.1.5.2 Organic Leachate	D-1-11
D.1.6 Uncertainties in Model Results	D-1-12
D.1.6.1 EQ3/6 Code Background	D-1-12
D.1.6.2 Limitations and Assumptions of Mineral Solubility Calculations	D-1-13
D.1.6.3 Uncertainty in Estimating Leachate Composition	D-1-13
D.2.0 Surface Water Modeling	D-2-1
D.2.1 Introduction	D-2-1
D.2.2 Conceptual Model	D-2-1
D.2.3 Surface Water Model Application	D-2-2
D.2.3.1 Model Assumptions	D-2-3
D.2.3.2 Calculation of Soil Loss from Runoff	D-2-3
D.2.3.3 Calculation of Contaminant Partitioning and Loading	D-2-4
D.2.4 Results of Surface Water Runoff Modeling	D-2-6
D.2.4.1 Comparison of Modeled Results to Measured Concentrations	D-2-6
D.2.5 Uncertainties in the Surface Water Model	D-2-7
D.2.6 Paddys Run Loading to the Great Miami Aquifer	D-2-7
D.2.6.1 Paddys Run Screening	D-2-7
D.2.6.2 SWIFT Loading from Paddys Run	D-2-9
References	D-2-11
D.3.0 Groundwater Fate and Transport Modeling	D-3-1
D.3.1 Introduction	D-3-1
D.3.1.1 Technical Approach	D-3-1
D.3.1.2 Approach to Screening and Modeling	D-3-3

OUI RI APPENDIX D TABLE OF CONTENTS

	<u>Page</u>
D.1.0 Geochemical Analysis	D-1-1
D.1.1 Introduction	D-1-1
D.1.2 Site-Specific Data	D-1-1
D.1.3 Development of the Conceptual Model	D-1-2
D.1.4 Estimation of Leachate Concentrations	D-1-3
D.1.4.1 Methodology for Inorganics and Radionuclides	D-1-3
D.1.4.2 Methodology for Organic Compounds	D-1-7
D.1.4.3 Estimation of Inorganic and Radionuclide Concentrations	D-1-7
D.1.4.4 Estimation of Organic Leachate	D-1-8
D.1.4.5 Summary	D-1-8
D.1.5 Discussion of Results and Observed Data	D-1-9
D.1.5.1 Leachate A and B for Inorganics and Radionuclides	D-1-9
D.1.5.2 Organic Leachate	D-1-11
D.1.6 Uncertainties in Model Results	D-1-12
D.1.6.1 EQ3/6 Code Background	D-1-12
D.1.6.2 Limitations and Assumptions of Mineral Solubility Calculations	D-1-13
D.1.6.3 Uncertainty in Estimating Leachate Composition	D-1-13
D.2.0 Surface Water Modeling	D-2-1
D.2.1 Introduction	D-2-1
D.2.2 Conceptual Model	D-2-1
D.2.3 Surface Water Model Application	D-2-2
D.2.3.1 Model Assumptions	D-2-3
D.2.3.2 Calculation of Soil Loss from Runoff	D-2-3
D.2.3.3 Calculation of Contaminant Partitioning and Loading	D-2-4
D.2.4 Results of Surface Water Runoff Modeling	D-2-6
D.2.4.1 Comparison of Modeled Results to Measured Concentrations	D-2-6
D.2.5 Uncertainties in the Surface Water Model	D-2-7
D.2.6 Paddys Run Loading to the Great Miami Aquifer	D-2-7
D.2.6.1 Paddys Run Screening	D-2-7
D.2.6.2 SWIFT Loading from Paddys Run	D-2-9
References	D-2-11
D.3.0 Groundwater Fate and Transport Modeling	D-3-1
D.3.1 Introduction	D-3-1
D.3.1.1 Technical Approach	D-3-1
D.3.1.2 Approach to Screening and Modeling	D-3-3

TABLE OF CONTENTS (Continued)

	<u>Page</u>
D.3.2 Hydrogeologic Setting	D-3-4
D.3.2.1 Geologic Setting	D-3-4
D.3.2.2 Vadose Zone	D-3-6
D.3.2.3 Great Miami Aquifer	D-3-8
D.3.2.4 General Contaminant Hydrogeology at the FEMP	D-3-8
D.3.3 Conceptual Model	D-3-9
D.3.3.1 Parameters	D-3-11
D.3.4 Constituent Screening and Review - Vadose Zone Pathway	D-3-13
D.3.4.1 Pre-Screening	D-3-14
D.3.4.2 Background Screening	D-3-14
D.3.4.3 Travel Time Screening	D-3-14
D.3.4.4 Initial Concentration Toxicity Screening	D-3-15
D.3.4.5 Vadose Zone Model Toxicity Screening	D-3-16
D.3.4.6 Review of Monitoring Data	D-3-16
D.3.4.7 Summary of CPCs	D-3-18
D.3.5 Perched Groundwater Concentrations	D-3-18
D.3.6 Vadose Zone Modeling	D-3-18
D.3.6.1 Models for Seepage Velocity	D-3-19
D.3.6.2 Model for Solute Transport (ODAST)	D-3-21
D.3.7 Aquifer Modeling	D-3-25
D.3.7.1 Description of Model, Background, And Development	D-3-25
D.3.7.2 SWIFT Modeling	D-3-28
D.3.8 Uncertainty in Modeling Results	D-3-32
D.3.8.1 HELP Model	D-3-32
D.3.8.2 ODAST Model	D-3-33
D.3.8.3 SWIFT Model	D-3-35
References	D-3-37
D.4.0 Air	D-4-1
D.4.1 Estimation of Radon Emission Flux-Reacom Model	D-4-1
D.4.2 Wind Erosion Emission Rate Calculation - Estimation of PM10 and TSP Emission Rate Due to Wind Erosion	D-4-3
D.4.3 Air Transport and Dispersion Modeling Protocol and Results	D-4-8
Attachment D.I On-Site Meteorological Data Star Summaries for 1987-1992	D-I-1
Attachment D.II Wind Rose Summaries for 1987-1992	D-II-1
Attachment D.III Sample ISCLT2 Model Output	D-III-1

0004

LIST OF TABLES

4787

<u>Table</u>	<u>Title</u>	<u>Page</u>
D.1-1	List of Potential Constituents of Concern for Operable Unit 1 RI	D-1-15
D.1-2	Source Characterization for Operable Unit 1 - Pit 1	D-1-16
D.1-3	Source Characterization for Operable Unit 1 - Pit 2	D-1-19
D.1-4	Source Characterization for Operable Unit 1 - Pit 3	D-1-22
D.1-5	Source Characterization for Operable Unit 1 - Pit 4	D-1-25
D.1-6	Source Characterization for Operable Unit 1 - Pit 5	D-1-28
D.1-7	Source Characterization for Operable Unit 1 - Pit 6	D-1-31
D.1-8	Source Characterization for Operable Unit 1 - Burn Pit	D-1-34
D.1-9	Source Characterization for Operable Unit 1 - Clearwell	D-1-37
D.1-10	Leachate A and Leachate B Compositions for Inorganics and Radionuclides in Operable Unit 1 - Pit 1	D-1-40
D.1-11	Leachate A and Leachate B Compositions for Inorganics and Radionuclides in for Operable Unit 1 - Pit 2	D-1-42
D.1-12	Leachate A and Leachate B Compositions for Inorganics and Radionuclides in Operable Unit 1 - Pit 3	D-1-44
D.1-13	Leachate A and Leachate B Compositions for Inorganics and Radionuclides in Operable Unit 1 - Pit 4	D-1-46
D.1-14	Leachate A and Leachate B Compositions for Inorganics and Radionuclides in Operable Unit 1 - Pit 5	D-1-48
D.1-15	Leachate A and Leachate B Compositions for Inorganics and Radionuclides in Operable Unit 1 - Pit 6	D-1-50
D.1-16	Leachate A and Leachate B Compositions for Inorganics and Radionuclides in Operable Unit 1 - Burn Pit	D-1-52
D.1-17	Leachate A and Leachate B Compositions for Inorganics and Radionuclides in Operable Unit 1 - Clearwell	D-1-54
D.1-18	Organic Leachate Concentrations in Operable Unit 1 - Pit 1	D-1-56
D.1-19	Organic Leachate Concentrations in Operable Unit 1 - Pit 2	D-1-58
D.1-20	Organic Leachate Concentrations in Operable Unit 1 - Pit 3	D-1-60
D.1-21	Organic Leachate Concentrations in Operable Unit 1 - Pit 4	D-1-62
D.1-22	Organic Leachate Concentrations in Operable Unit 1 - Pit 5	D-1-64
D.1-23	Organic Leachate Concentrations in Operable Unit 1 - Pit 6	D-1-66
D.1-24	Organic Leachate Concentrations in Operable Unit 1 - Burn Pit	D-1-68
D.1-25	Organic Leachate Concentrations in Operable Unit 1 - Clearwell	D-1-70
D.2-1	Available Potential Constituent of Concern Concentrations in Surface Soils at Operable Unit 1	D-2-12
D.2-2	Variables Used in the Surface Water Runoff Model	D-2-14

4787

LIST OF TABLES
(Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
D.2-3	Modeled Concentrations in Paddys Run and the Great Miami River	D-2-15
D.2-4	Comparison of Modeled Results to Measured Surface Water Concentrations in Paddys Run	D-2-17
D.2-5	Paddys Run Loading - Screening for SWIFT	D-2-18
D.2-6	Comparison of Selected 2000-Series Well Concentrations to Predicted Maximum Diluted Aquifer Concentrations	D-2-20
D.3-1	Waste Area Physical Parameters for Operable Unit 1 Modeling	D-3-40
D.3-2	Vadose Zone Model Input Parameters Operable Unit 1	D-3-41
D.3-3	Media Parameters for Vadose Zone Model Operable Unit 1	D-3-42
D.3-4	Retardation Factors and Decay Constants for Radionuclides at OU1	D-3-43
D.3-5	Retardation Factors for Inorganic Compounds at OU1	D-3-44
D.3-6	Retardation Factors and Biodegradation Coefficients for Organic Compounds at OU1	D-3-45
D.3-7	Screening Summary of Potential Constituents of Concern for Operable Unit 1	D-3-47
D.3-8	Input Parameters and Formulas for Travel Time Screening	D-3-51
D.3-9	Toxicity Screening for Constituents that Passed Travel Time Screening	D-3-52
D.3-10	Constituents Detected in Wells 2019, 2021, 2027, and 2648	D-3-53
D.3-11	Background Screening for Constituents Found in the Great Miami Aquifer and Potential Travel to Fenceline	D-3-54
D.3-12	Constituents of Concern Summary List	D-3-56
D.3-13	Projected Maximum Perched Water Concentrations	D-3-58
D.3-14	Summary of Loading Times and Concentrations for Constituents of Potential Concern	D-3-61
D.3-15	Source Areas for Operable Unit 1 Aquifer Model	D-3-62
D.3-16	Distribution Coefficients and Decay Factors for Compounds Modeled by SWIFT	D-3-63
D.3-17	Summary of Constituents of Potential Concern Predicted Maximum Concentrations in Groundwater	D-3-64
D.3-18	Maximum Concentrations of Constituent of Potential Concerns in Groundwater	D-3-66
D.3-19	Maximum Concentrations of Constituent of Potential Concerns at the Fenceline	D-3-67
D.3-20	Summary of Constituents of Potential Concern Predicted Maximum Concentrations in Groundwater Surface Water Pathway	D-3-68
D.3-21	Effect of Changes in Hydraulic Conductivity of the Till Layer on Seepage Rate	D-3-69
D.3-22	Effect of Varying Hydraulic Conductivities on Seepage Velocity	D-3-70
D.3-23	SWIFT Contaminant Transport Sensitivity Runs Using Waste Pit 1 Source	D-3-71
D.4-1	Dispersion Options Used in ISCLT Modeling of Operable Unit 1	D-4-14
D.4-2	Mixing Heights in Meters Used in ISCLT Modeling	D-4-15
D.4-3	Mixing Heights in Meters Used in ISCLT Modeling	D-4-17

LIST OF TABLES
(Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
D.4-4	Sources and Corresponding X and Y Coordinates for Operable Unit 1 Waste Pit Area Current Scenario	D-4-18
D.4-5	Sources and Corresponding X and Y Coordinates for Operable Unit 1 Waste Pit Area Future Scenario	D-4-19
D.4-6	Discrete Receptors and Distance for Origin	D-4-20
D.4-7	Maximum Concentrations (Unit Emission Rates) and Corresponding Locations for Current Scenario With Access Controls (On Site) and Without Access Controls Using 50 Meter Receptor Spacing	D-4-21
D.4-8	Maximum Off-Site Concentrations (Unit Emission Rates) and Corresponding Locations Current Scenario With Access Controls Using 50 Meter Receptor Spacing	D-4-23
D.4-9	Concentrations (Unit Emission Rates) at Discrete Receptors from All Operable Unit 1 Sources Relevant to Current Scenario	D-4-25
D.4-10	Maximum Concentrations (Unit Emission Rates) and Corresponding Locations for Future Scenario With Access Controls (On Site) and Without Access Controls Using 50 Meter Receptor Spacing	D-4-26
D.4-11	Maximum Off-Site Concentrations (Unit Emission Rates) and Corresponding Locations With Access Controls for Future Scenario Using 50 Meter Receptor Spacing	D-4-28
D.4-12	Concentrations (Unit Emission Rates) at Discrete Receptors from All Operable Unit 1 Sources Relevant to Future Scenario	D-4-30
D.4-13	Comparison of ISCLT2 Model Predictions to Ambient Radon Monitoring Data for the Base Year 1992	D-4-31

LIST OF FIGURES

4787

<u>Figure</u>	<u>Title</u>	<u>Page</u>
D.1-1	Conceptual Vadose Zone Model	D-1-72
D.1-2	Estimating Leachate for Radionuclides and Inorganics	D-1-73
D.1-3	Estimating Leachate for Organics	D-1-74
D.2-1	Conceptual Model of Surface Water Runoff	D-2-21
D.2-2	Topography and Natural Drainage Scenario of Operable Unit 1	D-2-22
D.2-3	Linear Extent of Paddys Run Infiltration to the Great Miami Aquifer and Locations of Selected 2000 Series Wells	D-2-23
D.2-4	Surface Water to Groundwater Pathway Transport Modeling Diagram	D-2-24
D.3-1	Vadose Zone Pathway Transport Modeling Diagram	D-3-72
D.3-2	Approach for Screening and Incorporation of Monitoring Data into the Modeling Process	D-3-73
D.3-3	Cases for Loading Constituents to the Great Miami Aquifer	D-3-74
D.3-4	Conceptual Model of Contaminant Transport by Groundwater at the FEMP	D-3-75
D.3-5	Conceptual Vadose Zone Model	D-3-76
D.3-6	Conceptual Diagram of Operable Unit 1 - Pit 1 and the Clearwell	D-3-77
D.3-7	Conceptual Diagram of Operable Unit 1 - Pit 2	D-3-78
D.3-8	Conceptual Diagram of Operable Unit 1 - Pit 3	D-3-79
D.3-9	Conceptual Diagram of Operable Unit 1 - Pit 4	D-3-80
D.3-10	Conceptual Diagram of Operable Unit 1 - Pit 5	D-3-81
D.3-11	Conceptual Diagram of Operable Unit 1 - Pit 6	D-3-82
D.3-12	Conceptual Diagram of Operable Unit 1 - Burn Pit	D-3-83
D.3-13	Potential Constituent of Concern Screening Diagram	D-3-84
D.3-14	SWIFT III Local Area Model Grid	D-3-85
D.3-15	Projected Concentration of Total Uranium in Groundwater Beneath FEMP After 100 Years Due to Loading from Operable Unit 1 Waste Areas	D-3-86
D.3-16	Projected Maximum Concentration of Total Uranium in Groundwater Beneath FEMP Due to Loading from Operable Unit 1 Waste Areas After 630 Years	D-3-87
D.3-17	Projected Concentration of Total Uranium in Groundwater Beneath FEMP After 1000 Years Due to Loading from Operable Unit 1 Waste Areas	D-3-88
D.3-18	Projected Concentration of Cyanide in Groundwater Beneath FEMP After 100 Years Due to Loading from Operable Unit 1 Waste Areas	D-3-89
D.3-19	Projected Maximum Concentration of Cyanide in Groundwater Beneath FEMP Due to Loading from Operable Unit 1 Waste Areas After 15 Years	D-3-90
D.3-20	Projected Concentration of Cyanide in Groundwater Beneath FEMP After 1000 Years Due to Loading from Operable Unit 1 Waste Areas	D-3-91
D.3-21	Projected Concentration of Tetrachloroethene in Groundwater Beneath FEMP After 100 Years Due to Loading from Operable Unit 1 Waste Areas	D-3-92

6603

4787

LIST OF FIGURES
(Continued)

<u>Figure</u>	<u>Title</u>	<u>Page</u>
D.3-22	Projected Maximum Concentration of Tetrachloroethene in Groundwater Beneath FEMP Due to Loading from Operable Unit 1 Waste Areas After 80 Years	D-3-93
D.3-23	Projected Concentration of Tetrachloroethene in Groundwater Beneath FEMP After 1000 Years Due to Loading from Operable Unit 1 Waste Areas	D-3-94
D.3-24	Projected Maximum Concentration of Total Uranium in Groundwater Beneath FEMP Due to Loading from Paddys Run After 10 Years	D-3-95
D.3-25	ODAST Model Sensitivity Analysis; Longitudinal Dispersion	D-3-96
D.3-26	ODAST Model Sensitivity Analysis; Darcy Velocity	D-3-97
D.3-27	ODAST Model Sensitivity Analysis; 1SP Layer Thickness	D-3-98
D.4-1	Operable Unit 1 Sources for Current Scenario, Fernald, Ohio	D-4-32
D.4-2	Operable Unit 1 Sources for Future Scenario, Fernald Ohio	D-4-33
D.4-3	OU-1 Coarse Modeling Grid	D-4-34
D.4-4	Refined Grid for On-Site Receptors, Fernald, Ohio	D-4-35
D.4-5	Refined Grid for Off-Site Receptors, Fernald, Ohio	D-4-36

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APPENDIX D.1.0
GEOCHEMICAL ANALYSIS

D.1.0 GEOCHEMICAL ANALYSIS

D.1.1 INTRODUCTION

The geochemical analysis was performed for source term and initial concentration development for the vadose zone and groundwater models. Analytical data for the Operable Unit 1 waste areas were compiled and screened to identify those potential constituents of concern based on the requirements of the Operable Unit 1 Baseline Risk Assessment (Appendix E). The Operable Unit 1 waste areas consist of Waste Pits 1 through 6, the Burn Pit, and the Clearwell. Potential constituents of concern for Operable Unit 1 (as defined in Appendix E) are listed in Table D.1-1.

This section

- Provides a summary of the site-specific data of interest to the geochemical analysis.
- Presents a conceptual model illustrating the formation of leachate and its migration into the groundwater.
- Outlines the geochemical assessment and modeling conducted to estimate contaminant concentrations in Leachates A and B for inorganics and radionuclides and in the organic leachate.
- Describes the EQ3/6 geochemical code used to perform mineral solubility calculations on Leachates A and B.
- Presents model results and other calculations.
- Summarizes the model uncertainty including the limitations and assumptions required for estimating leachate contaminant concentrations.

D.1.2 SITE-SPECIFIC DATA

Validated data used for deriving leachate concentrations from the waste areas were available from several sources:

- Characterization Investigation Study (CIS) Pit Material - Chemical and Radiological
- CIS Surface Water - Chemical
- Remedial Investigation/Feasibility Study (RI/FS) Pit Leachate - Chemical and Radiological
- RI/FS Pit Material - Chemical and Radiological
- Toxicity Characteristic Leaching Procedure (TCLP) - Chemical and Radiological

4787

These data sets are contained in Appendices A and C. Analytical data for the leachate data sets are most complete for the RI/FS data although pH, actinium, polonium, and protactinium are missing. TCLP extract was analyzed for 23 metals and the radionuclides cesium-237, radium-226, radium-228, thorium-228, thorium-230, strontium-90, thorium-232, uranium-234, uranium-235/236, and uranium-238. There are no general chemistry data for the TCLP data set. Limitations associated with the missing data are outlined when model results are discussed (Appendix E.2). Leachate data sets can be found in Section 4.0.

Tabulated results of waste area constituents based on direct sampling of the waste area sludges and their corresponding contaminant inventory are presented in Tables D.1-2 through D.1-9. To derive the contaminant inventory for each potential constituent of concern for each waste area, the maximum upper confidence limit concentration from the CIS or RI/FS Pit Material data sets for each potential constituent of concern was multiplied by the waste volume and dry density for that waste area (See Section D.3.0 for waste volume and dry density information).

D.1.3 DEVELOPMENT OF THE CONCEPTUAL MODEL

In the geochemical assessment of leachate formation, the events leading to the failure of the waste pits and exposure of the waste to precipitation are not considered. It is assumed that such failure does occur, and the waste is available for chemical reactions with falling precipitation followed by migration of leachate into underlying glacial deposits where further reactions take place. The conceptual scenario used to model the release of contaminants from Operable Unit 1 waste pits is illustrated in Figure D.1-1. For inorganics and radionuclides, rainwater infiltrates the waste pits and reacts with inorganic waste solids to form a waste leachate, referred to as Leachate A. Subsequently, Leachate A migrates into the underlying glacial overburden, if present, and reacts with the naturally occurring minerals to form a modified leachate, referred to as Leachate B. Leachate B is used to constrain the initial contaminant concentrations for the groundwater fate and transport model (vadose zone model in Section D.3.6). For organic constituents, a leachate concentration is derived from reaction of rainwater with solids. This leachate concentration is assumed to be unchanged by reaction with the glacial overburden materials.

As long as Leachate A remains in contact with the solid waste phases, the solution will retain its high pH property. However, when Leachate A migrates into the underlying glacial overburden, which is dominated by carbonate minerals, the solution chemistry of Leachate A will change to reflect the physical and chemical conditions of its new surrounding. Perched groundwater in the glacial overburden contains abundant bicarbonate ion (350 to 500 mg/L; (Table 15-1 DOE 1990b)), and it is expected that pore water will have a chemical composition similar to the perched groundwater. As Leachate A migrates into the glacial overburden it will mix with pore water, resulting in a pH decrease and possible mineral precipitation (e.g., $\text{Ca}^{+2} + \text{OH}^- + \text{HCO}_3^- \rightleftharpoons \text{CaCO}_3 + \text{H}_2\text{O}$). In this reaction, calcium and hydroxide ions provided by Leachate A are free to react with bicarbonate ion in the pore

0012

water to form calcite and water. Such a reaction is likely because the perched groundwater, and by inference the pore water, is calculated to be saturated with respect to calcite. This type of reaction, and many others, will modify Leachate A as it migrates into the glacial overburden, and this modified leachate is referred to as Leachate B. Therefore, the conceptual model is set up to account for the distinct chemical reactions that occur in the different environments.

Minerals in the glacial overburden underlying the waste units have been characterized (Solebello 1991). The minerals were titrated into a rainwater solution at various rates to simulate the development of groundwater collected from the glacial overburden. When results for major constituents in the modeled groundwater agreed with the range of values reported for groundwater collected from the glacial overburden, the corresponding mineral titration rates that produced the simulated groundwater were fixed for subsequent model runs involving Leachate A and glacial overburden minerals.

D.1.4 ESTIMATION OF LEACHATE CONCENTRATIONS

To estimate source terms for the Operable Unit 1 Study Area, the approach for estimating leachate concentrations for the inorganics and radionuclides was separated from the organics. Geochemical data collected for the Operable Unit 1 Study Area were assessed in conjunction with mineral solubility calculations to estimate contaminant concentrations in leachate at the base of each Operable Unit 1 waste unit (Leachate A in Figure D.1-1) and in modified leachate within the glacial overburden (Leachate B in Figure D.1-1). All contaminant concentrations used as input data in the fate and transport model are constrained by in situ leachate analyses, surface water analyses, TCLP data, mineral solubility calculations, or the EPA 70-year rule (EPA 1988). Figure D.1-2 summarizes the approach for estimating leachate compositions for radionuclides and inorganics and Figure D.1-3 summarizes the approach for estimating leachate compositions for organics. The relative ranking of these constraints and their use to estimate leachate concentrations are summarized in Figures D.1-2 and D.1-3. Results derived from the geochemical assessment and modeling (Tables D.1-10 through D.1-25) are used as initial contaminant concentrations in the vadose zone fate and transport model to predict contaminant concentrations at the top of the Great Miami Aquifer.

D.1.4.1 Methodology for Inorganics and Radionuclides

As shown in Figure D.1-2, the preferred data for estimating contaminant concentrations in Leachate A are analyses of in situ leachate. When these data are unavailable, an approach of using the best available data, the surface water or TCLP data, is followed. If in situ leachate or surface water analyses indicated that the compound was not detected and it was detected in the pit material for the subject waste area, then the concentration of the particular potential constituent of concern was conservatively estimated as the maximum detection limit value. TCLP data are screened to determine if the use of a contaminant concentration determined by the TCLP test would result in depletion of the contaminant inventory in less than 70-years. If the use of the TCLP concentration does not deplete the

October 12, 1993

contaminant inventory in less than 70 years it is used to estimate Leachate A, but if its use depletes the inventory in less than 70 years it is discarded and the contaminant concentration moves to the next level of the hierarchy, mineral solubility calculations. Mineral solubility calculations are carried out for contaminants that lack in situ and TCLP data, or for contaminants which fail the TCLP screening. Inorganic and radionuclide contaminants that lack in situ and TCLP data and cannot be constrained by mineral solubility calculations are passed along to the 70-year rule calculation to estimate their Leachate A calculation. After all contaminant concentrations in Leachate A are constrained, a computer simulation reacts Leachate A with the glacial overburden minerals to produce Leachate B.

The logic behind using this decision hierarchy is to apply the best available site-specific data to the estimation of leachate compositions. Each successively lower step on this hierarchy represents a more conservative method for estimating contaminant concentrations in leachate. For example, using TCLP when in situ or surface water data are unavailable results in estimating a leachate composition derived by leaching with acid rather than rain water. The acetic acid leaching results in greater concentrations for many metals in leachate because acetic acid degrades into the acetate ion, which is effective at complexing metals.

Contaminant concentrations in Leachate B are used as initial input concentrations in the vadose zone fate and transport model. If a lower contaminant solubility limit was not reached during the reaction of Leachate A with pore water (perched groundwater) or with glacial overburden minerals, contaminant concentrations in Leachate A and B are identical.

In modeling the conceptual scenario, Leachate A was constrained by in situ leachate or surface water analyses, TCLP data, and the 70-year rule prior to reacting Leachate A with glacial overburden or pore water. Leachate A exits at the base of Operable Unit 1 Study Area and migrates downward through the glacial overburden underlying the waste pits, where it is assumed to equilibrate with the minerals in the glacial overburden instantaneously. This assumption is a requirement of the mathematical model because of the lack of kinetic data on the dissolution and precipitation rates of minerals in the glacial overburden. Leachate A is free to react with minerals in the glacial overburden to form Leachate B, and the concentration of contaminants in the leachate may be lowered by precipitation of solids. Leachate B is used to estimate the initial contaminant concentrations for the vadose zone model.

In accordance with the conceptual scenario stated above, contaminant concentrations reported for Leachate B will be lower than those for Leachate A when dissolution/precipitation reactions between Leachate A and glacial overburden minerals result in a pH for Leachate B that corresponds to a solubility minimum for the mineral controlling the contaminant of concern. For example, beryllium oxide (BeO) is more soluble at pH values greater than 9 than those less than 9. Therefore, beryllium concentrations in Leachate A will be greater than those in Leachate B when pH values in Leachate A

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October 12, 1993

2787

are greater than 9 and in Leachate B less than 9. Conversely, contaminants in Leachate A that are controlled by in situ leachate analyses or TCLP values cannot increase their concentration in Leachate B by reaction with glacial overburden minerals, because waste elements are assumed to be absent in the glacial overburden. Therefore, contaminant concentrations in Leachate A are estimates of maximum values, and these values may only be lowered by reaction with glacial overburden minerals.

Leachate A is modified by dissolution of minerals in the glacial overburden or by mixing with pore water (perched groundwater) and precipitation of secondary mineral phases. Secondary minerals represent phases that are stable in the presence of Leachate A and glacial overburden, but may not be present in the glacial overburden initially. When the reactions between Leachate A and glacial overburden minerals achieve thermodynamic equilibrium, the modified leachate is referred to as Leachate B.

In Situ Leachate

In situ leachate reflects the complex interactions that take place between the waste solids and contact solution at the waste environment. Duplicating these conditions in laboratory tests is difficult and time consuming. The method describing the sampling and testing procedure can be found in the sampling and analysis plan (DOE 1992).

Toxicity Characteristic Leaching Procedure

When in situ leachate or surface water data are unavailable, available TCLP data are used to constrain the contaminant concentrations in Leachate A. TCLP data are derived by leaching the waste with acetic acid. The use of acetic acid as the leachant (rather than rainwater which acts as the leachant for in situ leachate) results in estimates of contaminant concentrations that may be too high. That is, a conservative uncertainty is likely to be introduced into the estimation of leachate compositions. This occurs because acetic acid degrades into the acetate ion, which is very effective at complexing heavy metals in solution and maintaining their concentrations above expected solubility levels.

Geochemical Modeling

For inorganics and radionuclides, mineral solubility calculations can be performed to estimate the concentration of constituents in Leachate A when in situ, surface water, or when TCLP data are unavailable or inappropriate. The concept of mineral solubility may be illustrated by placing the mineral cerussite (PbCO_3) into distilled water at 25 degrees C and a pressure of 1 atmosphere. Under these conditions, the equilibrium lead concentration in solution is 1.1 mg/L, which is referred to as the solubility limit for lead in distilled water contacting cerussite at 25 degrees C and 1 atmosphere.

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Mineral solubility calculations were performed to estimate leachate compositions using the EQ3/6 computer code and thermodynamic data on mineral solubilities. The calculation of contaminant concentrations from mineral solubility data was restricted to inorganic chemicals and radionuclides, as thermodynamic data for organic constituents are unavailable.

After all constituent concentrations in Leachate A have been constrained for inorganics and radionuclides, the second reaction step is modeled to estimate the constituent concentrations in Leachate B. Reactions between Leachate A and pore water and/or minerals in the glacial overburden can result in changes in solution pH and major-ion concentrations with concomitant mineral precipitation. These reactions may be favorable for lowering contaminant concentrations in Leachate A. The modeling of Leachate B accounts for this type of scenario. Therefore, if a contaminant concentration is lowered by chemical reactions in the glacial overburden, or with pore water, the lower concentration is used to estimate the composition of Leachate B. If a contaminant concentration is unaffected by chemical reactions in the glacial overburden, its Leachate B concentration is assumed to be identical to Leachate A. This last assumption results in a Leachate B concentration on the high side because dilution of Leachate A and adsorption of constituents of concern are not considered in the geochemical model (dilution and adsorption are considered in the fate and transport model).

Mineral solubility calculations can also be carried out using Leachate A and minerals present in the glacial overburden to derive Leachate B compositions. When mineral solubility calculations are performed, in situ leachate acts as the leachant and it is assumed to equilibrate with glacial till minerals or pore water instantaneously. This assumption is a requirement of the mathematical model because kinetic data on minerals are unavailable to assess the time needed for dissolution of mineral phases to occur. As the leachant approaches thermodynamic equilibrium with the till minerals or pore water, minerals dissolve to increase the solute mass (i.e., total dissolved solids [TDS] increases) and minerals that become saturated are allowed to precipitate. These reactions continue until the leachate reaches thermodynamic equilibrium with the till minerals or pore water (i.e., constituents in the leachate reach a steady-state concentration), at which point it is referred to as Leachate B.

Because the mineral solubility calculations to derive Leachate A require knowledge of the minerals present in the waste, and this knowledge is unavailable; therefore, no mineral solubility calculations were carried out for Leachate A. Therefore, none of the contaminant concentrations in Leachate A are constrained by mineral solubility calculations.

EPA 70-Year Rule

When in situ and TCLP data are lacking and mineral solubility calculations fail to constrain a contaminant concentration in Leachate A, the EPA 70-year rule is the suggested guidance for estimating leachate compositions (EPA 1988). The 70-year method is based on the assumption that

0016

the contaminant inventory will be depleted within this time period, which is assumed to equal the average lifetime of a human being.

D.1.4.2 Methodology for Organic Compounds

Figure D.1-3 illustrates the approach for estimating the leachate concentrations for organic compounds used in the vadose zone models. Each successively lower step in this hierarchy represents a more conservative method for estimating the contaminant concentrations in the organic leachate. In situ leachate analyses values were the preferred leachate information. As shown on the diagram, only one organic leachate concentration is derived for each organic compound. When in situ leachate analyses data were not available and CIS surface water analyses data were available, these values were used. If the analyses for either in situ leachate or CIS surface water analyses indicated the compound was not detected and it was detected in the pit material for the subject waste area, the concentration for a particular potential constituent of concern was conservatively estimated as the maximum detection limit value. When in situ leachate and CIS surface water analyses data were not available and TCLP data were available, these values were used if the contaminant inventory in the source volume is depleted in greater than 70 years. If the depleted time is less than 70 years, then the EPA 70-year rule is used to calculate the leachate concentrations.

Specific details for the use of TCLP and EPA 70-year rule as constraints in developing the organic leachate compositions are similar to those described in Section D.1.4.1 for Leachates A and B for inorganics and radionuclides and are not described in this section.

D.1.4.3 Estimation of Inorganic and Radionuclide Concentrations

Leachate A and B results are summarized in Tables D.1-10 through D.1-17. The estimation of the Leachates A and B for Operable Unit 1 waste areas is described below.

Leachate A

Leachate A was constrained by in situ or surface water analyses (or the maximum detection limit if no analysis for the particular element or constituent was above the detection limit), TCLP data, or the EPA's 70-year rule. Leachate B is the same as Leachate A for the wet pits (Pits 5 and 6, and the Clearwell) because of the lack of general chemistry data and incomplete chemical analyses of solid waste materials; therefore, no geochemical modeling of leachates was performed for Pits 5 and 6 and the Clearwell. For Pits 1, 2, and 3, Leachate B was calculated by reaction with the glacial overburden (till) minerals according to the decision hierarchy (Figure D.1-2). For Pit 4 and the Burn Pit, Leachate B was modeled by mixing (or titrating) Leachate A into a perched groundwater sample from well 1027 using mean values (bicarbonate was modeled by equilibrium with calcite) (Appendix C-4, February 1993 Operable Unit 1 Report). The minimum ratio of perched groundwater to Leachate A is 10:1. Usually a higher mixing ratio was sufficient to saturate the solution in those phases that would solubility limit Leachate B concentrations (e.g., barite, bromellite, calomel, silver metal, thorianite,

October 12, 1993

4787

etc.). The logic for using a glacial overburden pore water (perched groundwater) is that the interstitial aqueous fluids have had time to equilibrate with the glacial materials and thus there is no need to react till minerals with Leachate A. However, for Pits 1, 2, and 3, the perched groundwater sand lens is not present due to excavation, and Leachate B must be determined by geochemically modeling the reaction of Leachate A with till minerals.

Leachate B

After contaminant concentrations in Leachate A are estimated, the EQ3/6 geochemical code was utilized to obtain an estimate of Leachate B by simulating reactions between Leachate A and minerals in the glacial overburden or by mixing with perched groundwater (assumed pore water in glacial overburden). During this simulation, several mineral solubility limits were reached, and many contaminants have their concentration in Leachate B constrained by mineral solubility (Tables D.1-10 through D.1-17). More soluble elements, such as antimony, arsenic, boron, cadmium, cobalt, copper, cyanide, molybdenum, nickel, selenium, tin, and vanadium were not included in any geochemical modeling. Uranium was also not included in modeling because of its complexing with tributyl phosphate, which makes it more soluble than the model that does not include this organic contaminant. Seventy-year rule calculations were carried out in the wet pits (Pit 5, Pit 6, and the Clearwell) for cyanide (Pit 5), molybdenum (Pit 5 and the Clearwell), radium-226 (Pit 5), neptunium-237 (Clearwell) and tin (Pit 5, Pit 6, and the Clearwell) and for benzo(ghi)fluoranthene in Pit 2 using inventory data presented in Appendix A.

Results for Leachates A and B are summarized in Tables D.1-10 through D.1-17, and are discussed in Section D.1.5. These tables contain results for potential constituents of concern only, although major leachate constituents (anions and cations, e.g., Ca^{2+} , SO_4^{2-} , etc.) were modeled also.

D.1.4.4 Estimation of Organic Leachate

Organic leachate results are summarized in Tables D.1-18 through D.1-25. The estimation of the organic leachate for Operable Unit 1 waste areas is described below.

The organic leachate was constrained by in situ leachate for Pits 1, 2, 3, and 4 and the Burn Pit. Surface water analyses were available for Pits 5 and 6 and the Clearwell, and these were used to estimate in situ leachate compositions for several contaminants. TCLP data were not used to constrain any organic leachate concentrations. The 70-year Rule calculations were carried out for several organic constituents in Pit 3 and the Clearwell.

D.1.4.5 Summary

In summary, site-specific data are used to estimate Leachate A and organic leachate compositions when they are available and appropriate. Leachate compositions are generally estimated using a combination of in situ, surface water, and TCLP data. Constraining leachate compositions with in situ

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4787

constrained by TCLP data. After reacting Leachate A with glacial overburden minerals using EQ3/6, results for Leachate B (Table D.1-12) indicate that barium, beryllium, manganese, mercury, plutonium, silver, strontium, thorium, and zinc concentrations have been lowered by mineral solubility. The remaining contaminant concentrations in Leachate B are identical to Leachate A.

In Pit 4 (Table D.1-13), Leachate A concentrations for ammonia, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, cyanide, lead, manganese, molybdenum, nickel, plutonium, radium, selenium, silver, strontium, technetium, thorium, tin, uranium, vanadium, and zinc are constrained by in situ leachate analyses. Neptunium is constrained by TCLP data. After reacting Leachate A with pore water (perched groundwater) using EQ3/6, results for Leachate B (Table D.1-12) indicate that barium, chromium, manganese, mercury, neptunium, plutonium, silver, strontium, thorium, and vanadium concentrations have been lowered by mineral solubility. The remaining contaminant concentrations in Leachate B are identical to Leachate A.

Leachate A results for Pit 5 (Table D.1-14) show antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, vanadium, and zinc concentrations are constrained by TCLP data. Cesium, neptunium, plutonium, ruthenium, selenium, silver, strontium, technetium, thallium, thorium, and uranium are constrained by in situ or surface water analyses and cyanide, molybdenum, radium, and tin by the 70-year rule. All contaminant concentrations in Leachate B are identical to Leachate A.

For Pit 6 (Table D.1-15), analyses are available for arsenic, barium, beryllium, lead, manganese, nickel, silver, thallium, and zinc and these concentrations are constrained by TCLP; and cadmium, chromium, cobalt, copper, cesium, neptunium, plutonium, technetium, thorium, radium, strontium, uranium and vanadium, by surface water or in situ data. Only tin is constrained with the 70-year rule. All contaminant concentrations in Leachate B are identical to Leachate A.

Results for the Burn Pit (Table D.1-16) show antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, cyanide, lead, manganese, mercury, molybdenum, neptunium, nickel, plutonium, radium, selenium, silver, uranium, vanadium, and zinc concentrations are constrained by in situ leachate analyses. Technetium and thorium concentrations are set using TCLP data. After reacting Leachate A with pore water (perched groundwater) using EQ3/6, results for Leachate B (Table D.1-16) indicate that barium, beryllium, lead, manganese, mercury, neptunium, plutonium, silver, strontium, thorium, and zinc concentrations have been lowered by mineral solubility. The remaining contaminant concentrations in Leachate B are identical to Leachate A.

In the Clearwell all Leachate A concentrations (except Mo and Sn) are constrained by surface water data (Table D.1-17), TCLP data are unavailable and molybdenum, neptunium and tin concentrations

0020

are fixed using the 70-year rule. All contaminant concentrations in Leachate B are identical to Leachate A.

Several observations on the data presented in Tables D.1-10 through D.1-17 warrant further discussion to clarify differences in reported concentrations for a given element. For any given contaminant concentration constrained by the 70-year rule, its concentration in Leachate A or B is proportional to its inventory abundance in the waste unit. Therefore, a waste unit with a higher contaminant inventory will yield a higher contaminant concentration when the 70-year rule is applied. In general, the same argument can be applied to contaminant concentrations constrained by TCLP data. That is, a waste unit with a higher contaminant inventory will generally yield a higher TCLP concentration for that element.

D.1.5.2 Organic Leachate

Results for organic leachate concentrations for Pits 1 through 6, the Burn Pit, and Clearwell are presented in Tables D.1-18 through D.1-25, respectively. While the entire list of potential organic constituents of concern for Operable Unit 1 as defined in Table D.1-1 are shown on each of these tables, leachate concentrations are provided only for organic constituents detected in the pit materials for the subject waste area.

In situ leachate analyses were available for organic constituents of concern for Pits 1, 2, 3, 4, and the Burn Pit (Tables D.1-18, D.1-19, D.1-20, D.1-21, and D.1-24). When the in situ leachate analyses indicated that the constituent was not detected, the organic leachate concentration was conservatively estimated as the maximum detection limit value.

CIS surface water analyses were available for Pits 5 and 6 and the Clearwell (Tables D.1-22, D.1-23, and D.1-25). For all constituents except Aroclor-1254 and tetrachloroethene in Pit 6, constituents of concern were not detected and the organic leachate concentration was conservatively estimated as the maximum detection limit value.

TCLP data were not used to constrain any organic leachate concentrations.

The EPA 70-year rule was used to calculate organic leachate concentrations for benzo(g,h,i)fluoranthene in Pit 2 (Table D.1-19), acenaphthylene and pentachlorophenol in Pit 3 (Table D.1-20), and the majority of the constituents of concern in the Clearwell (Table D.1-25).

D.1.6 UNCERTAINTIES IN MODEL RESULTS

D.1.6.1 EQ3/6 Code Background

Mineral solubility calculations were performed with the EQ3/6 industry-standard geochemical computer code. EQ3/6 was developed at Lawrence Livermore National Laboratory (Wolery 1983; Daveler and Wolery 1992; Wolery 1992 a,b,c) for predicting the behavior of metals, radionuclides, and other contaminants in the natural environment. The EQ3/6 computer code performs solubility and speciation (aqueous form) calculations and reaction-path modeling. These calculations involve the simultaneous solution of equations describing the mass balance of each component, mass action expressions for solubility equilibrium, oxidation/reduction reactions, and electrical balance constraints. Activity coefficients of aqueous species are approximated with the B-dot equation of Helgeson (1969), which are valid up to the ionic strength of seawater (about 0.7). None of the leachate samples modeled for Operable Unit 1 waste units exceeded an ionic strength of 0.2.

The EQ3/6 code accesses a data base containing the thermodynamic properties of 78 elements, 862 aqueous species, 886 minerals, and 76 gases. This data base includes 57 aqueous uranium species and 160 uranium-bearing minerals, constituting the most complete data base available for modeling the behavior of uranium in natural waters. EQ3/6 has been validated using standard geochemistry problems, such as the speciation of seawater (Nordstrom 1979), basalt/seawater interactions (Bowers et al. 1985), and numerous comparisons with experimentally determined mineral solubilities (Jackson 1988). Benchmark comparisons with the results of similar codes (e.g., PHREEQE) have been performed by INTERA (1983), Nordstrom (1979), Kincaid and Morey (1984), and Kerrisk (1981).

EQ3 is the portion of the code that calculates the initial aqueous species distribution with user-provided concentration data and computes the saturation indices (SI) of pertinent minerals. The SI is defined as $\log(Q/K)$, where Q equals the ion activity product and K equals equilibrium constant. An SI of greater than zero, zero, and less than zero corresponds to a mineral that is supersaturated, saturated, and undersaturated, respectively. After computing the speciation model, EQ3 computes a mass balance for each chemical element and performs a charge balance. This information is stored in a file that is used as input to EQ6. EQ3 differs from EQ6 in that EQ3 identifies minerals that are supersaturated and undersaturated, but (unlike EQ6) EQ3 cannot precipitate and dissolve the pertinent minerals.

The EQ6 code performs reaction-path calculations. Reaction-path (chemical evolution) modeling simulates a sequence of thermodynamic equilibrium problems in reacting systems consisting of water and minerals or other solids. The reacting system may consist of water that migrates through, and equilibrates with, waste solids and natural minerals in compositionally distinct horizons. For this case, rainwater reacts with Operable Unit 1 waste to form Leachate A followed by migration and reaction with underlying glacial overburden minerals to form Leachate B. The chemical evolution of the

reacting system is driven by dissolution and precipitation of minerals or solids and/or by changes in temperature and pressure. Along each step of the reaction path, the EQ6 code computes the precipitation and dissolution of minerals based on mass action expressions for solubility equilibrium with water. Thus, EQ6 differs from EQ3 by allowing supersaturated minerals (SI greater than 0) to precipitate from solution and undersaturated minerals (SI less than 0) to dissolve.

D.1.6.2 Limitations and Assumptions of Mineral Solubility Calculations

The EQ3/6 geochemical code estimates contaminant concentrations by calculating mineral solubilities in water/solid systems. These calculations have the following limitations and assumptions:

- Limited number of organic constituents can be modeled, which can lead to low estimates of leachate concentrations for some inorganic constituents if organic complexation occurs with constituents not present in the database (e.g., lead complexed with acetate ion).
- Dissolution and precipitation kinetics are instantaneous, which can lead to estimated concentrations that are too high or too low.
- Adsorption processes are not evaluated with the EQ3/6 model.
- Modeled concentrations are site-specific solubility limits, and in most cases these concentrations are the highest concentrations that can exist in solution.

Dissolution of crystalline solids is rarely instantaneous or complete in the natural environment, except for some highly soluble salts like sodium chloride, which can lead to high estimates of contaminant concentrations. Assuming instantaneous precipitation of mineral phases can lead to low estimates of element concentrations if the mineral such as dolomite is difficult to nucleate and crystallize in the natural environment (e.g., dolomite). Finally, the calculated solubility concentrations may be too high because adsorption reactions are not considered. Adsorption reactions can substantially lower some contaminant concentrations below the calculated solubility limit (e.g., Cs⁺).

D.1.6.3 Uncertainty in Estimating Leachate Compositions

Uncertainty is introduced into the estimation of leachate compositions whenever in situ leachate analyses are lacking. Surface water analyses used to estimate leachate composition probably reflect diluted in situ leachate residing within the void space of the waste. Given that dilution will occur when the leachate migrates into the underlying glacial overburden, the use of actual surface water analyses probably introduces less uncertainty than other types of data or methods used to calculate the leachate composition. The use of TCLP data to estimate leachate composition will probably result in contaminant concentrations that are greater than values expected for in situ leachate. As mentioned previously, this occurs due to the breakdown of acetic acid to acetate ion followed by the complexation of metals in the leachate. Calculations carried out to estimate contaminant concentrations using the 70-year rule will introduce a large conservative uncertainty for all but the

most soluble contaminants (e.g., bromide and cesium). The possibility exists to underestimate the contaminant concentration when the 70-year rule is applied to very soluble constituents. Using the EQ3/6 geochemical code to perform mineral solubility calculations requires that several assumptions be made about the mineralogy of the waste, the kinetics of the reactions, and the lack of treatment of organic constituents. The uncertainties associated with these assumptions are discussed in Section D.1.6.2.

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0024

October 12, 1993

TABLE D.1-1

LIST OF POTENTIAL CONSTITUENTS OF CONCERN FOR OPERABLE UNIT 1 RI

Potential Constituents of Concern*		
<u>Inorganics</u>	2,3,4,7,8-	Indeno(1,2,3-cd)pyrene
Antimony	Pentachlorodibenzofuran	Naphthalene
Arsenic	2,4,5-Trichlorophenol	Octachlorodibenzofuran
Barium	4,4-DDT	Octachlorodibenzo-p-dioxin
Beryllium	4-Nitroaniline	Pentachlorophenol
Boron	4-Nitrophenol	Phenanthrene
Cadmium	Acenaphthene	Pyrene
Chromium	Anthracene	Tetrachlorodibenzofuran
Cobalt	Aroclor-1221	Tetrachloroethene
Copper	Aroclor-1248	Vinyl Chloride
Cyanide	Aroclor-1254	
Lead	Aroclor-1260	<u>Radionuclides</u>
Manganese	Benzo(a)anthracene	Cesium-137
Mercury	Benzo(a)pyrene	Neptunium-237
Molybdenum	Benzo(b)fluoranthene	Plutonium-238
Nickel	Benzo(ghi)perylene	Plutonium-239/240
Selenium	Benzo(ghi)fluoranthene	Radium-226
Silver	Benzo(k)fluoranthene	Ruthenium-106
Thallium	Chrysene	Strontium-90
Tin	Dibenzo(a,h)anthracene	Technetium-99
Vanadium	Dichlorodifluoromethane	Thorium-230
Zinc	Fluoranthene	Thorium-232
	Fluorene	Uranium-234
<u>Organics</u>	Heptachlorodibenzofuran	Uranium-235
1,2,3,7,8-	Heptachlorodibenzo-p-dioxin	Uranium-238
Pentachlorodibenzofuran	Hexachlorodibenzofuran	
	Hexachlorodibenzo-p-dioxin	

*List of potential constituents of concern represent union of constituents detected in any OU1 Waste Area.

0025

4787

TABLE D.1-2

SOURCE CHARACTERIZATION FOR OPERABLE UNIT 1 - PIT 1

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Radionuclides		
Cesium-137	1.26×10^{-8}	7.78×10^{-1}
Neptunium-237	NA ^e	0.00
Plutonium-238	NA	0.00
Plutonium-239/240	NA	0.00
Radium-226	8.76×10^{-5}	5.39×10^3
Ruthenium-106	NA	0.00
Strontium-90	3.44×10^{-8}	2.12×10^0
Technetium-99	8.84×10^{-4}	5.44×10^4
Thorium-230	2.70×10^{-1}	1.66×10^7
Thorium-232	1.20×10^3	7.37×10^{10}
Uranium-234	1.44×10^{-1}	8.89×10^6
Uranium-235/236 ^f	8.28×10^1	5.10×10^9
Uranium-238	3.12×10^4	1.92×10^{12}
Inorganics		
Antimony	8.89×10^1	5.47×10^9
Arsenic	1.13×10^1	6.96×10^8
Barium	4.05×10^2	2.49×10^{10}
Beryllium	8.21×10^0	5.05×10^8
Boron	1.22×10^3	7.52×10^{10}
Cadmium	1.62×10^1	9.95×10^8
Chromium	2.26×10^2	1.39×10^{10}
Cobalt	3.38×10^1	2.08×10^9
Copper	8.00×10^1	4.93×10^9
Cyanide	7.3×10^{-1}	4.49×10^7
Lead	3.66×10^1	2.25×10^9
Manganese	2.13×10^3	1.31×10^{11}
Mercury	3.0×10^{-1}	1.85×10^7

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TABLE D.1-2
(Continued)

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Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Molybdenum	2.57×10^1	1.58×10^9
Nickel	4.71×10^1	2.90×10^9
Selenium	NA	0.00
Silver	1.22×10^2	7.54×10^9
Thallium	4.6×10^{-1}	2.83×10^7
Tin	NA	0.00
Vanadium	9.57×10^1	5.89×10^9
Zinc	3.67×10^1	2.26×10^9
Organics		
1,2,3,7,8-Pentachlorodibenzofuran	5.42×10^{-3}	3.34×10^5
2,3,4,7,8-Pentachlorodibenzofuran	7.50×10^{-4}	4.62×10^4
2,4,5-Trichlorophenol	NA	0.00
4,4-DDT	1.60×10^0	9.85×10^7
4-Nitrophenol	NA	0.00
4-Nitroaniline	NA	0.00
Ancenaphthene	NA	0.00
Anthracene	7.4×10^{-2}	4.56×10^{10}
Aroclor-1221	4.60×10^0	2.83×10^8
Aroclor-1248	7.07×10^0	4.35×10^8
Aroclor-1254	9.98×10^0	6.14×10^8
Aroclor-1260	7.80×10^0	4.80×10^8
Benzo(a)anthracene	1.80×10^1	1.11×10^7
Benzo(a)pyrene	1.40×10^1	8.62×10^6
Benzo(b)fluoranthene	3.07×10^1	1.89×10^7
Benzo(ghi)perylene	NA	0.00
Benzo(ghi)fluoranthene	NA	0.00
Benzo(k)fluoranthene	1.40×10^1	8.62×10^6
Chrysene	4.51×10^{-1}	2.78×10^7
Dibenzo(a,h)anthracene	NA	0.00

TABLE D.1-2
(Continued)

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Dichlorodifluoromethane	2.96×10^1	1.82×10^9
Fluoranthene	1.00×10^0	6.16×10^7
Fluorene	NA	0.00
Heptachlorodibenzofuran	1.75×10^{-3}	1.08×10^5
Heptachlorodibenzo-p-dioxin	1.45×10^{-3}	8.93×10^4
Hexachlorodibenzofuran	2.26×10^{-3}	1.39×10^5
Hexachlorodibenzo-p-dioxin	3.21×10^{-3}	1.98×10^5
Indeno(1,2,3-cd)pyrene	NA	0.00
Naphthalene	6.7×10^{-2}	4.12×10^6
Octachlorodibenzofuran	7.60×10^{-4}	4.68×10^4
Octachlorodibenzo-p-dioxin	5.40×10^{-4}	3.32×10^4
Pentachlorophenol	NA	0.00
Phenanthrene	1.88×10^0	1.16×10^8
Pyrene	4.9×10^{-1}	3.02×10^7
Tetrachlorodibenzofuran	2.84×10^{-2}	1.75×10^6
Tetrachloroethene	2.52×10^{-1}	1.55×10^7
Vinyl Chloride	NA	0.00

^aUranium-235 in CIS Pit Materials Data Base.

^bUCL - Upper Confidence Limit on mean values were extracted from statistical summaries presented in Appendix D.

^cAll concentrations in milligrams per kilogram.

^dTotal mass in milligrams.

^eNA - Not detected or not analyzed in the CIS or RI/FS Pit Materials Data sets.

0028

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TABLE D.1-3

4787

SOURCE CHARACTERIZATION FOR OPERABLE UNIT 1 - PIT 2

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Radionuclides		
Cesium-137	4.14×10^{-8}	1.00×10^0
Neptunium-237	NA ^e	0.00
Plutonium-238	5.84×10^{-9}	1.41×10^{-1}
Plutonium-239/240	9.65×10^{-6}	2.34×10^2
Radium-226	8.59×10^{-4}	2.08×10^4
Ruthenium-106	1.40×10^{-9}	3.40×10^{-2}
Strontium-90	2.93×10^{-8}	7.10×10^{-1}
Technetium-99	3.64×10^{-2}	8.82×10^5
Thorium-230	9.11×10^{-1}	2.21×10^7
Thorium-232	2.45×10^3	5.93×10^{10}
Uranium-234	1.84×10^0	4.47×10^7
Uranium-235/236 ^a	2.55×10^3	6.18×10^{10}
Uranium-238	3.56×10^4	8.63×10^{11}
Inorganics		
Antimony	5.88×10^1	1.43×10^9
Arsenic	3.80×10^2	9.22×10^9
Barium	1.95×10^3	4.74×10^{10}
Beryllium	2.68×10^1	6.50×10^8
Boron	2.48×10^2	6.01×10^9
Cadmium	1.35×10^1	3.27×10^8
Chromium	2.94×10^2	7.12×10^9
Cobalt	1.32×10^3	3.21×10^{10}
Copper	1.26×10^3	3.05×10^{10}
Cyanide	2.64×10^0	6.40×10^7
Lead	8.48×10^2	2.06×10^{10}
Mercury	2.81×10^0	6.81×10^7
Manganese	2.66×10^3	6.44×10^{10}

8500

0029

4787

TABLE D.1-3
(Continued)

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Molybdenum	1.93×10^2	4.68×10^9
Nickel	1.58×10^3	3.83×10^{10}
Selenium	1.14×10^2	2.75×10^9
Silver	4.10×10^1	9.94×10^8
Thallium	2.40×10^0	5.82×10^7
Tin	NA	0.0
Vanadium	5.29×10^2	1.28×10^{10}
Zinc	2.07×10^3	5.02×10^{10}
Organics		
1,2,3,7,8-Pentachlorodibenzofuran	5.50×10^{-4}	1.33×10^4
2,3,4,7,8-Pentachlorodibenzofuran	NA	0.00
2,4,5-Trichlorophenol	NA	0.00
4,4-DDT	1.40×10^0	3.39×10^7
4-Nitroaniline	4.90×10^0	1.19×10^8
4-Nitrophenol	1.90×10^{-1}	4.61×10^6
Acenaphthene	4.30×10^1	1.04×10^9
Anthracene	7.56×10^1	1.83×10^9
Aroclor-1221	NA	0.00
Aroclor-1248	4.90×10^0	1.19×10^8
Aroclor-1254	3.23×10^{-1}	7.83×10^6
Aroclor-1260	NA	0.00
Benzo(a)anthracene	1.00×10^2	2.42×10^9
Benzo(a)pyrene	7.57×10^1	1.83×10^9
Benzo(b)fluoranthene	1.30×10^2	3.15×10^9
Benzo(ghi)perylene	4.20×10^1	1.02×10^9
Benzo(ghi)fluoranthene	1.20×10^0	2.91×10^7
Benzo(k)fluoranthene	4.73×10^1	1.15×10^9
Chrysene	8.60×10^1	2.08×10^9
Dibenzo(a,h)anthracene	2.00×10^{-2}	4.85×10^5

TABLE D.1-3
(Continued)

4787

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Dichlorodifluoromethane	NA	0.00
Fluoranthene	3.09×10^2	7.49×10^9
Fluorene	6.20×10^1	1.50×10^9
Heptachlorodibenzofuran	5.90×10^3	1.43×10^5
Heptachlorodibenzo-p-dioxin	8.10×10^{-3}	1.96×10^5
Hexachlorodibenzofuran	2.70×10^{-3}	6.54×10^4
Hexachlorodibenzo-p-dioxin	3.20×10^{-4}	7.76×10^3
Indeno(1,2,3-cd)pyrene	4.60×10^1	1.12×10^9
Naphthalene	2.30×10^1	5.58×10^8
Octachlorodibenzofuran	4.90×10^{-3}	1.19×10^5
Octachlorodibenzo-p-dioxin	4.59×10^{-2}	1.11×10^6
Pentachlorophenol	1.60×10^0	3.88×10^7
Phenanthrene	1.56×10^2	3.77×10^9
Pyrene	1.58×10^2	3.84×10^9
Tetrachlorodibenzofuran	NA	0.00
Tetrachloroethene	4.50×10^{-2}	1.09×10^6
Vinyl Chloride	7.242E+02	1.756E+07

^aUranium-235 in CIS Pit Materials Data Base.

^bUCL - Upper Confidence Limit on mean values were extracted from statistical summaries presented in Appendix D.

^cAll concentrations in milligrams per kilogram.

^dTotal mass in milligrams

^eNA - Not detected or not analyzed in the CIS or RI/FS Pit Materials data sets.

TABLE D.1-4

SOURCE CHARACTERIZATION FOR OPERABLE UNIT 1 - PIT 3

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Radionuclides		
Cesium-137	NA ^e	0.00
Neptunium-237	2.97×10^{-3}	6.17×10^5
Plutonium-238	5.84×10^{-8}	1.21×10^1
Plutonium-239/240	2.25×10^{-4}	4.67×10^4
Radium-226	3.10×10^{-4}	6.43×10^4
Ruthenium-106	NA	0.00
Strontium-90	3.81×10^{-8}	7.91×10^0
Technetium-99	3.07×10^{-2}	6.37×10^6
Thorium-230	4.25×10^{-1}	8.81×10^7
Thorium-232	3.62×10^3	7.51×10^{11}
Uranium-234	1.78×10^{-1}	3.70×10^7
Uranium-235/236 ^a	3.38×10^1	7.01×10^9
Uranium-238	3.86×10^3	8.02×10^{11}
Inorganics		
Antimony	5.25×10^1	1.09×10^{10}
Arsenic	2.13×10^4	4.42×10^{12}
Barium	8.08×10^3	1.68×10^{12}
Beryllium	1.44×10^1	2.99×10^9
Boron	1.55×10^2	3.22×10^{10}
Cadmium	2.59×10^1	5.38×10^9
Chromium	1.86×10^2	3.86×10^{10}
Cobalt	3.60×10^1	7.46×10^9
Copper	1.74×10^3	3.62×10^{11}
Cyanide	1.61×10^0	3.34×10^8
Lead	6.70×10^2	1.39×10^{11}
Manganese	1.67×10^4	3.47×10^{12}
Mercury	3.19×10^0	6.62×10^8

TABLE D.1-4
(Continued)

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Molybdenum	2.41×10^2	5.00×10^{10}
Nickel	2.66×10^2	5.52×10^{10}
Selenium	4.95×10^1	1.03×10^{10}
Silver	3.74×10^1	7.77×10^9
Thallium	1.20×10^1	2.49×10^9
Tin	1.91×10^2	3.96×10^{10}
Vanadium	5.20×10^3	1.08×10^{12}
Zinc	3.11×10^2	6.45×10^{10}
Organics		
1,2,3,7,8-Pentachlorodibenzofuran	NA	0.00
2,3,4,7,8-Pentachlorodibenzo-p-dioxin	NA	0.00
2,4,5-Trichlorophenol	NA	0.00
4,4-DDT	NA	0.00
4-Nitroaniline	NA	0.00
4-Nitrophenol	NA	0.00
Acenaphthene	9.6×10^2	1.99×10^7
Anthracene	1.30×10^{-1}	2.70×10^7
Aroclor-1221	NA	0.00
Aroclor-1248	2.73×10^0	5.66×10^8
Aroclor-1254	2.08×10^0	4.31×10^8
Aroclor-1260	NA	0.00
Benzo(a)anthracene	3.60×10^1	7.47×10^7
Benzo(a)pyrene	3.80×10^1	7.89×10^7
Benzo(b)fluoranthene	5.60×10^{-1}	1.16×10^8
Benzo(ghi)perylene	1.60×10^{-1}	3.32×10^7
Benzo(ghi)fluoranthene	NA	0.00
Benzo(k)fluoranthene	NA	0.00
Chrysene	3.70×10^{-1}	7.68×10^7
Dibenzo(a,h)anthracene	NA	0.00

0033

October 12, 1993

4787

TABLE D.1-4
(Continued)

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Dichlorodifluoromethane	NA	0.00
Fluoranthene	7.20×10^{-1}	1.49×10^8
Fluorene	NA	0.00
Heptachlorodibenzofuran	6.90×10^{-4}	1.43×10^5
Heptachlorodibenzo-p-dioxin	2.10×10^{-3}	4.36×10^5
Hexachlorodibenzofuran	2.70×10^{-4}	5.60×10^4
Hexachlorodibenzo-p-dioxin	2.60×10^{-4}	5.40×10^4
Indeno(1,2,3-cd)pyrene	1.30×10^{-1}	2.70×10^7
Naphthalene	NA	0.00
Octachlorodibenzofuran	7.50×10^{-4}	1.56×10^5
Octachlorodibenzo-p-dioxin	1.27×10^{-2}	2.64×10^6
Pentachlorophenol	1.30×10^0	2.70×10^8
Phenanthrene	5.80×10^{-1}	1.20×10^8
Pyrene	6.20×10^{-1}	1.29×10^8
Tetrachlorodibenzofuran	2.00×10^{-4}	4.15×10^4
Tetrachloroethene	1.07×10^{-2}	2.21×10^6
Vinyl Chloride	NA	0.00

^aUranium-235 in CIS Pit Materials Data Base.

^bUCL - Upper Confidence Limit on mean values were extracted from statistical summaries presented in Appendix D.

^cAll concentrations in milligrams per kilogram.

^dTotal mass in milligrams.

^eNA - Not detected or not analyzed in the CIS or RI/FS Pit Materials data sets.

0034

2966

TABLE D.1-5

SOURCE CHARACTERIZATION FOR OPERABLE UNIT 1 - PIT 4

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Radionuclides		
Cesium-137	NA ^e	0.00
Neptunium-237	5.67×10^{-4}	4.37×10^4
Plutonium-238	2.92×10^{-8}	2.25×10^0
Plutonium-239/240	6.43×10^{-6}	4.96×10^2
Radium-226	3.70×10^{-5}	2.85×10^3
Ruthenium-106	NA	0.00
Strontium-90	7.28×10^{-7}	5.61×10^1
Technetium-99	1.16×10^{-2}	8.93×10^5
Thorium-230	7.51×10^{-2}	5.79×10^6
Thorium-232	6.47×10^3	$4.99E \times 10^{11}$
Uranium-234	6.57×10^{-1}	5.06×10^7
Uranium-235/236 ^a	3.24×10^2	2.50×10^{10}
Uranium-238	1.33×10^5	1.02×10^{13}
Inorganics		
Antimony	2.22×10^2	1.71×10^{10}
Arsenic	5.16×10^0	3.98×10^8
Barium	4.58×10^3	3.53×10^{11}
Beryllium	5.06×10^1	3.90×10^9
Boron	6.58×10^2	5.07×10^{10}
Cadmium	2.45×10^1	1.89×10^9
Chromium	1.05×10^3	8.09×10^{10}
Cobalt	1.29×10^2	9.96×10^9
Copper	3.52×10^2	2.72×10^{10}
Cyanide	7.0×10^{-1}	5.40×10^7
Lead	5.53×10^1	4.26×10^9
Manganese	4.75×10^3	3.66×10^{11}
Mercury	6.2×10^{-1}	4.78×10^7

0035

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4787
TABLE D.1-5
(Continued)

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Molybdenum	6.98×10^1	5.38×10^9
Nickel	1.67×10^2	1.29×10^{10}
Selenium	3.7×10^{-1}	2.85×10^7
Silver	5.31×10^2	4.10×10^{10}
Thallium	NA	0.00
Tin	1.14×10^2	8.76×10^9
Vanadium	3.94×10^2	3.04×10^{10}
Zinc	1.43×10^2	1.10×10^{10}
Organics		
1,2,3,7,8-Pentachlorodibenzofuran	1.08×10^{-2}	8.33×10^5
2,3,4,7,8-Pentachlorodibenzofuran	1.74×10^{-3}	1.34×10^5
2,4,5-Trichlorophenol	NA	0.00
4,4-DDT	NA	0.00
4-Nitroaniline	NA	0.00
4-Nitrophenol	2.30×10^0	1.77×10^8
Acenaphthene	1.90×10^0	1.46×10^8
Anthracene	2.70×10^0	2.08×10^8
Aroclor-1221	NA	0.00
Aroclor-1248	5.92×10^0	4.57×10^8
Aroclor-1254	6.80×10^0	5.24×10^8
Aroclor-1260	NA	0.00
Benzo(a)anthracene	4.70×10^0	3.62×10^8
Benzo(a)pyrene	4.50×10^0	3.47×10^8
Benzo(b)fluoranthene	5.20×10^0	4.01×10^8
Benzo(ghi)perylene	9.90×10^1	7.63×10^7
Benzo(ghi)fluoranthene	NA	0.00
Benzo(k)fluoranthene	3.70×10^0	2.85×10^8
Chrysene	3.86×10^0	2.98×10^8
Dibenzo(a,h)anthracene	6.5×10^{-2}	5.01×10^6

TABLE D.1-5
(Continued)

787

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Dichlorodifluoromethane	NA	0.00
Fluoranthene	1.10×10^1	8.48×10^8
Fluorene	2.20×10^0	1.70×10^8
Heptachlorodibenzofuran	3.18×10^3	2.45×10^5
Heptachlorodibenzo-p-dioxin	3.16×10^{-3}	2.44×10^5
Hexachlorodibenzofuran	5.39×10^{-3}	4.16×10^5
Hexachlorodibenzo-p-dioxin	1.85×10^{-3}	1.43×10^5
Indeno(1,2,3-cd)pyrene	9.90×10^{-1}	7.63×10^7
Naphthalene	1.10×10^0	8.48×10^7
Octachlorodibenzofuran	3.66×10^{-3}	2.82×10^5
Octachlorodibenzo-p-dioxin	6.52×10^{-3}	5.03×10^5
Pentachlorophenol	NA	0.00
Phenanthrene	1.20×10^1	9.25×10^8
Pyrene	9.00×10^0	6.94×10^8
Tetrachlorodibenzofuran	3.11×10^{-2}	2.40×10^6
Tetrachloroethene	3.00×10^1	2.31×10^9
Vinyl Chloride	1.40×10^1	1.079×10^6

^aUranium-235 in CIS Pit Materials Data Base.

^bUCL - Upper Confidence Limit on mean values were extracted from statistical summaries presented in Appendix D.

^cAll concentrations in milligrams per kilogram.

^dTotal mass in milligrams.

^eNA - Not detected or not analyzed in the CIS or RI/FS Pit Materials data sets.

4787

TABLE D.1-6

SOURCE CHARACTERIZATION FOR OPERABLE UNIT 1 - PIT 5

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Radionuclides		
Cesium-137	8.73×10^{-7}	6.26×10^1
Neptunium-237	6.52×10^{-2}	4.67×10^6
Plutonium-238	2.10×10^{-7}	1.51×10^1
Plutonium-239/240	1.56×10^{-4}	1.12×10^4
Radium-226	1.13×10^{-4}	8.10×10^3
Ruthenium-106	4.77×10^{-10}	3.42×10^{-2}
Strontium-90	1.47×10^{-7}	1.06×10^1
Technetium-99	1.22×10^{-1}	8.74×10^6
Thorium-230	3.37×10^{-1}	2.42×10^7
Thorium-232	4.12×10^2	2.95×10^{10}
Uranium-234	1.49×10^{-1}	1.07×10^7
Uranium-235/236 ^a	2.49×10^1	1.79×10^9
Uranium-238	2.69×10^3	1.93×10^{11}
Inorganics		
Antimony	5.17×10^1	3.71×10^9
Arsenic	2.15×10^3	1.54×10^{11}
Barium	3.02×10^4	2.17×10^{12}
Beryllium	1.48×10^1	1.06×10^9
Boron	NA ^e	0.00
Cadmium	1.16×10^1	8.32×10^8
Chromium	1.16×10^2	8.30×10^9
Cobalt	3.55×10^1	2.55×10^9
Copper	1.18×10^4	8.47×10^{11}
Cyanide	5.0×10^{-1}	3.59×10^7
Lead	1.74×10^2	1.25×10^{10}
Manganese	3.05×10^3	2.19×10^{11}
Mercury	1.60×10^0	1.15×10^8

TABLE D.1-6
(Continued)

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Molybdenum	6.66×10^2	4.78×10^{10}
Nickel	1.50×10^2	1.08×10^{10}
Selenium	1.38×10^1	9.90×10^8
Silver	1.41×10^1	1.01×10^9
Thallium	3.45×10^1	2.48×10^9
Tin	4.80×10^1	3.44×10^9
Vanadium	4.92×10^3	3.53×10^{11}
Zinc	2.06×10^2	1.48×10^{10}
Organics		
1,2,3,7,8-Pentachlorodibenzofuran	NA	0.00
2,3,4,7,8-Pentachlorodibenzofuran	NA	0.00
2,4,5-Trichlorophenol	NA	0.00
4,4-DDT	NA	0.00
4-Nitroaniline	NA	0.00
4-Nitrophenol	NA	0.00
Acenaphthene	NA	0.00
Anthracene	NA	0.00
Aroclor-1221	NA	0.00
Aroclor-1248	5.50×10^{-1}	3.94×10^7
Aroclor-1254	7.50×10^{-1}	5.38×10^7
Aroclor-1260	NA	0.00
Benzo(a)anthracene	NA	0.00
Benzo(a)pyrene	NA	0.00
Benzo(b)fluoranthene	NA	0.00
Benzo(ghi)perylene	NA	0.00
Benzo(ghi)fluoranthene	NA	0.00
Benzo(k)fluoranthene	NA	0.00
Chrysene	NA	0.00
Dibenzo(a,h)anthracene	NA	0.00

TABLE D.1-6
(Continued)

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Dichlorodifluoromethane	NA	0.00
Fluoranthene	NA	0.00
Fluorene	NA	0.00
Heptachlorodibenzofuran	NA	0.00
Heptachlorodibenzo-p-dioxin	NA	0.00
Hexachlorodibenzofuran	NA	0.00
Hexachlorodibenzo-p-dioxin	NA	0.00
Indeno(1,2,3-cd)pyrene	NA	0.00
Naphthalene	NA	0.00
Octachlorodibenzofuran	NA	0.00
Octachlorodibenzo-p-dioxin	NA	0.00
Pentachlorophenol	NA	0.00
Phenanthrene	NA	0.00
Pyrene	NA	0.00
Tetrachlorodibenzofuran	NA	0.00
Tetrachloroethene	NA	0.00
Vinyl Chloride	NA	0.00

^aUranium-235 in CIS Pit Materials Data Base.

^bUCL - Upper Confidence Limit on mean values were extracted from statistical summaries presented in Appendix D.

^cAll concentrations in milligrams per kilogram.

^dTotal mass in milligrams.

^eNA - Not detected or not analyzed in the CIS or RI/FS Pit Materials data sets.

TABLE D.1-7

SOURCE CHARACTERIZATION FOR OPERABLE UNIT 1 - PIT 6

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Radionuclides		
Cesium-137	3.56×10^{-7}	4.05×10^0
Neptunium-237	4.82×10^{-3}	5.48×10^4
Plutonium-238	7.59×10^{-8}	8.63×10^{-1}
Plutonium-239/240	2.30×10^{-4}	2.62×10^3
Radium-226	4.45×10^{-6}	5.06×10^1
Ruthenium-106	NA ^e	0.00
Strontium-90	4.03×10^8	4.58×10^{-1}
Technetium-99	9.83×10^{-3}	1.12×10^5
Thorium-230	2.36×10^{-3}	2.68×10^4
Thorium-232	1.00×10^1	1.14×10^8
Uranium-234	8.11×10^{-1}	9.23×10^6
Uranium-235/236 ^a	8.53×10^2	9.71×10^9
Uranium-238	6.13×10^4	6.98×10^{11}
Inorganics		
Antimony	NA	0.00
Arsenic	5.49×10^1	6.25×10^8
Barium	9.50×10^1	1.08×10^9
Beryllium	5.70×10^0	6.49×10^{-7}
Boron	NA	0.00
Cadmium	5.70×10^0	6.49×10^7
Chromium	3.00×10^1	3.41×10^8
Cobalt	2.60×10^1	2.96×10^8
Copper	2.22×10^2	2.53×10^9
Cyanide	NA	0.00
Lead	7.96×10^1	9.05×10^8
Manganese	2.21×10^2	2.51×10^9
Mercury	NA	0.00

47871

TABLE D.1-7
(Continued)FEMP-01RI-4 DRAFT
October 12, 1993

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Molybdenum	NA	0.00
Nickel	5.10×10^1	5.80×10^8
Selenium	NA	0.00
Silver	1.58×10^2	1.80×10^9
Thallium	7.10×10^1	8.08×10^8
Tin	1.38×10^1	1.57×10^8
Vanadium	1.00×10^2	1.14×10^9
Zinc	4.80×10^1	5.46×10^8
Organics		
1,2,3,7,8-Pentachlorodibenzofuran	NA	0.00
2,3,4,7,8-Pentachlorodibenzofuran	NA	0.00
2,4,5-Trichlorophenol	NA	0.00
4,4-DDT	NA	0.00
4-Nitroaniline	NA	0.00
4-Nitrophenol	NA	0.00
Acenaphthene	NA	0.00
Anthracene	NA	0.00
Aroclor-1221	NA	0.00
Aroclor-1248	NA	0.00
Aroclor-1254	8.10×10^{-2}	9.22×10^5
Aroclor-1260	NA	0.00
Benzo(a)anthracene	NA	0.00
Benzo(a)pyrene	NA	0.00
Benzo(b)fluoranthene	NA	0.00
Benzo(ghi)perylene	NA	0.00
Benzo(ghi)fluoranthene	NA	0.00
Benzo(k)fluoranthene	NA	0.00
Chrysene	NA	0.00
Dibenzo(a,h)anthracene	NA	0.00
Dichlorodifluoromethane	NA	0.00

TABLE D.1-7
(Continued)

FEMP-01RI-4 DRAFT
October 12, 1993

4782

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Fluoranthene	NA	0.00
Fluorene	NA	0.00
Heptachlorodibenzofuran	NA	0.00
Heptachlorodibenzo-p-dioxin	NA	0.00
Hexachlorodibenzofuran	NA	0.00
Hexachlorodibenzo-p-dioxin	NA	0.00
Indeno(1,2,3-cd)pyrene	NA	0.00
Naphthalene	NA	0.00
Octachlorodibenzofuran	NA	0.00
Octachlorodibenzo-p-dioxin	NA	0.00
Pentachlorophenol	NA	0.00
Phenanthrene	NA	0.00
Pyrene	NA	0.00
Tetrachlorodibenzofuran	NA	0.00
Tetrachloroethene	3.11 x 10 ¹	3.53 x 10 ⁸
Vinyl Chloride	NA	0.00

^aUranium-235 in CIS Pit Materials Data Base.

^bUCL - Upper Confidence Limit on mean values were extracted from statistical summaries presented in Appendix D.

^cAll concentrations in milligrams per kilogram.

^dTotal mass in milligrams.

^eNA - Not detected or not analyzed in the CIS or RI/FS Pit Materials data sets.

TABLE D.1-8

SOURCE CHARACTERIZATION FOR OPERABLE UNIT 1 - BURN PIT

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Radionuclides		
Cesium-137	NA ^e	0.00
Neptunium-237	8.50×10^{-4}	2.22×10^4
Plutonium-238	2.92×10^{-8}	7.64×10^{-1}
Plutonium-239/240	6.43×10^{-6}	1.68×10^2
Radium-226	3.46×10^{-5}	9.05×10^2
Ruthenium-106	NA	0.00
Strontium-90	3.66×10^{-9}	9.59×10^{-2}
Technetium-99	3.08×10^{-3}	8.07×10^4
Thorium-230	1.89×10^{-1}	4.94×10^6
Thorium-232	1.32×10^2	3.44×10^9
Uranium-234	2.49×10^{-1}	6.53×10^6
Uranium-235/236 ^a	4.69×10^1	1.23×10^9
Uranium-238	5.36×10^3	1.40×10^{11}
Inorganics		
Antimony	1.78×10^1	4.66×10^8
Arsenic	3.47×10^1	9.09×10^8
Barium	3.05×10^3	7.97×10^{10}
Beryllium	7.10×10^0	1.86×10^8
Boron	4.82×10^1	1.26×10^9
Cadmium	1.54×10^1	4.03×10^8
Chromium	9.25×10^1	2.42×10^9
Cobalt	9.89×10^1	2.59×10^9
Copper	2.81×10^2	7.36×10^9
Cyanide	2.10×10^{-1}	5.50×10^6
Lead	3.10×10^2	8.11×10^9
Manganese	9.44×10^{-2}	2.47×10^{10}
Mercury	1.2×10^0	3.14×10^7

TABLE D.1-8
(Continued)

4787

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Molybdenum	2.49×10^1	6.52×10^8
Nickel	1.87×10^2	4.88×10^9
Selenium	1.91×10^0	5.00×10^7
Silver	5.06×10^2	1.32×10^{10}
Thallium	5.00×10^{-1}	1.31×10^7
Tin	NA	0.00
Vanadium	1.30×10^2	3.39×10^9
Zinc	5.23×10^2	1.37×10^{10}
Organics		
1,2,3,7,8-Pentachlorodibenzofuran	NA	0.00
2,3,4,7,8-Pentachlorodibenzofuran	NA	0.00
2,4,5-Trichlorophenol	NA	0.00
4,4-DDT	NA	0.00
4-Nitroaniline	NA	0.00
4-Nitrophenol	NA	0.00
Acenaphthene	1.10×10^0	2.88×10^7
Anthracene	3.10×10^0	8.12×10^7
Aroclor-1221	NA	0.00
Aroclor-1248	NA	0.00
Aroclor-1254	7.70×10^0	2.02×10^8
Aroclor-1260	NA	0.00
Benzo(a)anthracene	6.30×10^0	1.65×10^8
Benzo(a)pyrene	3.90×10^0	1.02×10^8
Benzo(b)fluoranthene	9.60×10^0	2.51×10^8
Benzo(ghi)perylene	2.90×10^0	7.59×10^7
Benzo(ghi)fluoranthene	NA	0.00
Benzo(k)fluoranthene	3.40×10^{-1}	8.90×10^6
Chrysene	7.00×10^0	1.83×10^8
Dibenzo(a,h)anthracene	NA	0.00

TABLE D.1-8
(Continued)

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Dichlorodifluoromethane	NA	0.00
Fluoranthene	1.60×10^1	4.19×10^8
Fluorene	1.70×10^0	4.45×10^7
Heptachlorodibenzofuran	NA	0.00
Heptachlorodibenzo-p-dioxin	9.80×10^4	2.57×10^4
Hexachlorodibenzofuran	NA	0.00
Hexachlorodibenzo-p-dioxin	NA	0.00
Indeno(1,2,3-cd)pyrene	2.20×10^0	5.76×10^7
Naphthalene	2.00×10^{-1}	1.05×10^5
Octachlorodibenzofuran	1.30×10^{-4}	3.40×10^3
Octachlorodibenzo-p-dioxin	4.00×10^{-3}	1.05×10^5
Pentachlorophenol	2.60×10^0	6.81×10^7
Phenanthrene	1.50×10^1	3.93×10^8
Pyrene	1.40×10^1	3.67×10^8
Tetrachlorodibenzofuran	NA	0.00
Tetrachloroethene	2.60×10^{-1}	6.81×10^6
Vinyl Chloride	3.00×10^0	7.854×10^4

^aUranium-235 in CIS Pit Materials Data Base.

^bUCL - Upper Confidence Limit on mean values were extracted from statistical summaries presented in Appendix D.

^cAll concentrations in milligrams per kilogram.

^dTotal mass in milligrams.

^eNA - Not detected or not analyzed in the CIS or RI/FS Pit Materials data sets.

TABLE D.1-9

4787

SOURCE CHARACTERIZATION FOR OPERABLE UNIT 1 - CLEARWELL

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Radionuclides		
Cesium-137	4.66×10^{-6}	3.49×10^1
Neptunium-237	3.12×10^{-3}	2.34×10^4
Plutonium-238	2.33×10^{-8}	1.75×10^{-1}
Plutonium-239/240	6.43×10^{-6}	4.82×10^1
Radium-226	1.19×10^{-4}	8.91×10^2
Ruthenium-106	NA ^e	0.00
Strontium-90	1.63×10^{-7}	1.22×10^0
Technetium-99	3.08×10^{-2}	2.31×10^5
Thorium-230	2.36×10^{-1}	1.77×10^6
Thorium-232	3.37×10^2	2.53×10^9
Uranium-234	1.28×10^{-1}	9.57×10^5
Uranium-235/236 ^a	1.61×10^2	1.2×10^9
Uranium-238	4.05×10^3	3.03×10^{10}
Inorganics		
Antimony	3.20×10^1	2.40×10^8
Arsenic	5.40×10^1	4.05×10^8
Barium	6.14×10^3	4.60×10^{10}
Beryllium	7.80×10^0	5.85×10^7
Boron	NA	0.00
Cadmium	7.20×10^0	5.40×10^7
Chromium	1.53×10^2	1.15×10^9
Cobalt	2.30×10^1	1.72×10^8
Copper	2.42×10^3	1.81×10^{10}
Cyanide	9.20×10^0	6.90×10^7
Lead	4.33×10^2	3.25×10^9
Manganese	1.32×10^4	9.93×10^{10}
Mercury	4.80×10^0	3.60×10^7

0047

4787

TABLE D.1-9
(Continued)

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Molybdenum	3.65×10^1	2.74×10^8
Nickel	1.67×10^2	1.25×10^9
Selenium	3.70×10^0	2.77×10^0
Silver	9.84×10^0	7.38×10^0
Thallium	2.10×10^0	1.57×10^7
Tin	1.82×10^1	1.36×10^8
Vanadium	2.20×10^3	1.65×10^{10}
Zinc	2.46×10^2	1.85×10^9
Organics		
1,2,3,7,8-Pentachlorodibenzofuran	NA	0.00
2,3,4,7,8-Pentachlorodibenzofuran	NA	0.00
2,4,5-Trichlorophenol	6.20×10^0	4.65×10^7
4,4-DDT	NA	0.00
4-Nitroaniline	NA	0.00
4-Nitrophenol	NA	0.00
Acenaphthene	NA	0.00
Anthracene	4.50×10^{-1}	3.37×10^6
Aroclor-1221	NA	0.00
Aroclor-1248	3.08×10^{-1}	2.31×10^6
Aroclor-1254	6.44×10^{-1}	4.82×10^6
Aroclor-1260	NA	0.00
Benzo(a)anthracene	8.90×10^{-1}	6.67×10^6
Benzo(a)pyrene	6.70×10^{-1}	5.02×10^6
Benzo(b)fluoranthene	7.10×10^{-1}	5.32×10^6
Benzo(ghi)perylene	2.30×10^{-1}	1.72×10^6
Benzo(ghi)fluoranthene	NA	0.00
Benzo(k)fluoranthene	7.50×10^{-1}	5.62×10^6
Chrysene	1.00×10^0	7.50×10^6
Dibenzo(a,h)anthracene	NA	0.00

TABLE D.1-9
(Continued)

4787

Potential Constituents of Concern	UCL on Mean Concentration in Pit Material ^{b,c}	Contaminant Inventory in the Waste ^d
Dichlorodifluoromethane	NA	0.00
Fluoranthene	3.10×10^0	2.32×10^7
Fluorene	2.80×10^{-1}	2.10×10^6
Heptachlorodibenzofuran	NA	0.00
Heptachlorodibenzo-p-dioxin	NA	0.00
Hexachlorodibenzofuran	NA	0.00
Hexachlorodibenzo-p-dioxin	NA	0.00
Naphthalene	NA	0.00
Indeno(1,2,3-cd)pyrene	2.70×10^{-1}	2.02×10^6
Octachlorodibenzofuran	NA	0.00
Octachlorodibenzo-p-dioxin	NA	0.00
Pentachlorophenol	NA	0.00
Phenanthrene	1.79×10^0	1.34×10^7
Pyrene	1.40×10^0	1.05×10^7
Tetrachlorodibenzofuran	NA	0.00
Tetrachloroethene	NA	0.00
Vinyl Chloride	NA	0.00

^aUranium-235 in CIS Pit Materials Data Base.

^bUCL - Upper Confidence Limit on mean values were extracted from statistical summaries presented in Appendix D.

^cAll concentrations in milligrams per kilogram.

^dTotal mass in milligrams.

^eNA - Not detected or not analyzed in the CIS or RI/FS Pit Materials data sets.

TABLE D.1-10

LEACHATE A AND LEACHATE B COMPOSITIONS
FOR INORGANICS AND RADIONUCLIDES IN
OPERABLE UNIT 1 - PIT 1

Element	Leachate A Concentration ^a	Constraint ^b	Leachate B Concentration ^a	Constraint ^b
pH	11.8 SU	NA ^c	6.75 SU	EQ3/6
Eh	-0.190 V	NA	+0.400 V	EQ3/6
Antimony	0.3225	ISL	0.3225	ISL
Arsenic	0.0028	ISL	0.0028	ISL
Barium	1.9236	ISL	1.9236	ISL
Beryllium	0.0774	ISL	1.83×10^{-3}	BeO
Boron	1.2279	ISL	1.2279	ISL
Cadmium	0.0414	ISL	0.0414	ISL
Cesium-137 ^d	1.2×10^{-10}	mdl-ISL	1.2×10^{-10}	mdl-ISL
Chromium	0.1929	ISL	3.42×10^{-4}	CrO ₂
Cobalt	1.3215	ISL	1.3215	ISL
Copper	0.0832	ISL	0.0832	ISL
Cyanide	0.5437	ISL	0.5437	ISL
Lead	0.0048	ISL	0.0048	ISL
Manganese	208.3633	ISL	0.0771	carb.SS ^e
Mercury	0.0002	ISL	1.8×10^{-10}	calomel
Molybdenum	0.3605	ISL	0.3605	ISL
Neptunium-237				
Nickel	8.2943	ISL	8.2943	ISL
Nitrate	194.7	ISL	194.7	ISL
Plutonium-238				
Plutonium-239 and 240				
Radium-226 ^d	1.213×10^{-7}	ISL	1.213×10^{-7}	ISL
Ruthenium-106				
Selenium				
Silver	0.1181	ISL	0.1181	ISL

TABLE D.1-10
(Continued)

4787

Element	Leachate A Concentration ^a	Constraint ^b	Leachate B Concentration ^a	Constraint ^b
Strontium-90 ^d	9.12×10^{-11}	ISL	2.84×10^{-14}	carb.SS
Technetium-99 ^d	2.18×10^{-6}	TCLP	2.18×10^{-6}	TCLP
Thorium-230	2.57×10^{-8}	mdl-ISL	2.08×10^{-9}	ThO ₂
Thorium-232	0.0046	mdl-ISL	2.08×10^{-9}	ThO ₂
Thorium-Total ^d	0.0015	mdl-ISL	2.08×10^{-9}	ThO ₂
Uranium-234 ^d	5.75×10^{-4}	ISL	5.75×10^{-4}	ISL
Uranium-235 ^d	1.24×10^{-1}	ISL	1.24×10^{-1}	ISL
Uranium-238 ^d	11.93	ISL	11.93	ISL
Uranium-Total ^d	10.8615	ISL	10.86	ISL
Vanadium	0.1103	ISL	0.1103	ISL
Zinc	0.2115	ISL	3.54×10^{-4}	carb.SS

- ^a Element concentrations in milligrams per liter (ppm), pH in standard units (SU), and Eh in Volts (V). Blank spaces indicate that the constituent was not detected or analyzed in waste pit materials, therefore no leachate concentration was derived and the waste unit was assumed to have 0 source for that constituent.
- ^b Constraint on reported concentration is by EQ3/6 Geochemical Code (EQ3/6) Toxicity Characteristic Leaching Procedure (TCLP), in situ leachate (ISL), maximum detection limit (mdl), US EPA 70-year rule (70-year), or by solubility with respect to the indicated mineral phase.
- ^c NA = Not applicable.
- ^d Radioactive constituent. Formula for conversion of aqueous radioactivity to concentration of radionuclide in solution:
 $\text{mg/l} = 2.798 \times 10^{-15} \cdot (\text{gram formula wt}) \cdot (\text{Activity in pCi/l}) \cdot (\text{half-life in years})$
- ^e carb.SS is carbonate solid solution which includes calcite, magnesite, rhodochrosite, siderite, strontianite, and smithsonite components.

0051

4782

TABLE D.1-11

LEACHATE A AND LEACHATE B COMPOSITIONS
FOR INORGANICS AND RADIONUCLIDES IN
OPERABLE UNIT 1 - PIT 2

Element	Leachate A Concentration ^a	Constraint ^b	Leachate B Concentration ^a	Constraint ^b
pH	10.3 SU	NA ^c	6.52 SU	EQ3/6
Eh	-0.108 V	NA	+0.415 V	EQ3/6
Ammonia	275.	ISL	275.	ISL
Antimony	0.571	ISL	0.571	ISL
Arsenic	0.0677	ISL	0.0677	ISL
Barium	0.449	ISL	0.1564	barite
Beryllium	0.0057	ISL	0.004	BeO
Boron	2.82	ISL	2.82	ISL
Cadmium	0.279	ISL	0.279	ISL
Cesium-137	1.2×10^{-10}	mdl-ISL	1.2×10^{-10}	mdl-ISL
Chromium	0.0889	ISL	4.59×10^{-4}	CrO ₂
Cobalt	0.595	ISL	0.595	ISL
Copper	0.145	ISL	0.145	ISL
Cyanide	0.0316	ISL	0.0316	ISL
Lead	0.0183	ISL	0.0183	ISL
Manganese	4.52	ISL	3.93×10^{-3}	carb.SS ^d
Mercury	0.0046	ISL	9.8×10^{-11}	calomel
Molybdenum	1.57	ISL	1.57	ISL
Neptunium-237 ^e				
Nickel	0.189	ISL	0.189	ISL
Nitrate	4,650.	ISL	4,650.	ISL
Plutonium-238	2.9×10^{-11}	mdl-ISL	6.59×10^{-11}	PuO ₂
Plutonium-239 and 240	8.03×10^{-9}	mdl-ISL	6.59×10^{-11}	PuO ₂
Radium-226 ^e	2.82×10^{-7}	ISL	2.82×10^{-7}	ISL
Ruthenium-106	2.24×10^{-11}	mdl-ISL	2.24×10^{-11}	mdl-ISL
Selenium	0.0583	ISL	0.0583	ISL

TABLE D.1-11
(Continued)

Element	Leachate A Concentration ^a	Constraint ^b	Leachate B Concentration ^a	Constraint ^b
Silver	0.115	ISL	0.115	ISL
Strontium-90 ^c	4.7×10^{-11}	ISL	3.14×10^{-14}	carb.ss
Technetium-99 ^c	5.33×10^{-6}	TCLP	5.33×10^{-6}	TCLP
Thallium	0.0055	ISL	0.0055	ISL
Thorium-230	9.3×10^{-8}	TCLP	2.05×10^{-9}	ThO ₂
Thorium-232	0.0046	mdl-TCLP	2.05×10^{-9}	ThO ₂
Thorium-Total ^e	0.0084	TCLP	2.05×10^{-9}	thorianite
Tin				
Uranium-234 ^c	1.74×10^{-4}	ISL	1.74×10^{-4}	ISL
Uranium-235 ^c	3.68×10^{-2}	ISL	3.68×10^{-2}	ISL
Uranium-238 ^c	3.73	ISL	3.73	ISL
Uranium-Total ^e	3.65	ISL	3.65	ISL
Vanadium	0.334	ISL	0.334	ISL
Zinc	0.063	ISL	2.44×10^{-4}	carb.SS

^a Element concentrations in milligrams per liter (ppm), pH in standard units (SU), and Eh in Volts (V). Blank spaces indicate that the constituent was not detected or analyzed in waste pit materials, therefore no leachate concentration was derived and the waste unit was assumed to have 0 source for that constituent.

^b Constraint on reported concentration is by EQ3/6 Geochemical Code (EQ3/6) Toxicity Characteristic Leaching Procedure (TCLP), in situ leachate (ISL), maximum detection limit (mdl), US EPA 70-year rule, or by solubility with respect to the indicated mineral phase.

^c NA = Not applicable.

^d carb.SS is carbonate solid solution which includes calcite, magnesite, rhodochrosite, siderite, strontianite, and smithsonite components.

^e Radioactive constituent. Formula for conversion of aqueous radioactivity to concentration of radionuclide in solution:

$$\text{mg/l} = 2.798 \times 10^{-15} \cdot (\text{gram formula wt}) \cdot (\text{Activity in pCi/l}) \cdot (\text{half-life in years})$$

^f No concentration units have been specified for F and NO₃ in the data sets but these are assumed in ppm of mg/l.

TABLE D.1-12

LEACHATE A AND LEACHATE B COMPOSITIONS
FOR INORGANICS AND RADIONUCLIDES IN
OPERABLE UNIT 1 - PIT 3

Element	Leachate A Concentration ^a	Constraint ^b	Leachate B Concentration ^a	Constraint ^b
pH	7.7 SU	NA ^c	6.54 SU	EQ3/6
Eh	+0.115 V	NA	+0.118 V	EQ3/6
Ammonia	2,625.	ISL	2,625.	ISL
Antimony	0.656	ISL	0.656	ISL
Arsenic	1.49	ISL	1.49	ISL
Barium	0.526	ISL	0.061	barite
Beryllium	0.0081	ISL	0.0041	BeO
Boron	5.48	ISL	5.48	ISL
Cadmium	0.311	ISL	0.311	ISL
Cesium-137 ^d				
Chromium	0.182	ISL	0.182	ISL
Cobalt	0.137	ISL	0.137	ISL
Copper	0.782	ISL	0.782	ISL
Cyanide	1.27	ISL	1.27	ISL
Lead	1.61	ISL	1.61	ISL
Manganese	132.	ISL	0.197	carb.SS ^e
Mercury	0.0988	ISL	2.16×10^{-11}	calomel
Molybdenum	2.8	ISL	2.8	ISL
Nickel	0.0473	ISL	0.0473	ISL
Nitrate	6,574.	ISL	6,574.	ISL
Plutonium-238 ^d	2.9×10^{-11}	mdl-ISL	2.9×10^{-11}	mdl-ISL
Plutonium-239 and 240	8.03×10^{-9}	mdl-ISL	6.9×10^{-11}	PuO ₂
Radium-226 ^d	1.95×10^{-8}	TCLP	1.95×10^{-8}	TCLP
Ruthenium-106 ^d				
Selenium	0.14	ISL	0.14	ISL
Silver	0.165	ISL	0.0285	Ag

4787

FEMP-01RI-4 DRAFT
October 12, 1993

TABLE D.1-12
(Continued)

Element	Leachate A Concentration ^a	Constraint ^b	Leachate B Concentration ^a	Constraint ^b
Strontium-90 ^d	7.5×10^{-10}	ISL	8.3×10^{-13}	carb.SS
Technetium-99 ^d	2.06×10^{-5}	ISL	2.06×10^{-5}	ISL
Thallium	0.107	ISL	0.107	ISL
Thorium-230 ^d	5.5×10^{-8}	TCLP	1.95×10^{-9}	ThO ₂
Thorium-232 ^d	0.0046	mdl-TCLP	1.95×10^{-9}	ThO ₂
Thorium-Total ^d	0.0029	mdl-TCLP	1.95×10^{-9}	ThO ₂
Tin	0.2	ISL	0.2	ISL
Uranium-234 ^d	2.57×10^{-4}	ISL	2.57×10^{-4}	ISL
Uranium-235 ^d	0.0367	ISL	0.0367	ISL
Uranium-238 ^d	7.42	ISL	7.42	ISL
Uranium-Total ^d	4.96	ISL	4.96	ISL
Vanadium	1.24	ISL	1.24	ISL
Zinc	0.158	ISL	1.16×10^{-3}	carb.SS

^a Element concentrations in milligrams per liter (ppm), pH in standard units (SU), and Eh in Volts (V). Blank spaces indicate that the constituent was not detected or analyzed in waste pit materials, therefore no leachate concentration was derived and the waste unit was assumed to have 0 source for that constituent.

^b Constraint on reported concentration is by EQ3/6 Geochemical Code (EQ3/6) Toxicity Characteristic Leaching Procedure (TCLP), in situ leachate (ISL), maximum detection limit (mdl), US EPA 70-year rule, or by solubility with respect to the indicated mineral phase.

^c NA = Not applicable.

^d Radioactive constituent. Formula for conversion of aqueous radioactivity to concentration of radionuclide in solution:

$$\text{mg/l} = 2.798 \times 10^{-15} \cdot (\text{gram formula wt}) \cdot (\text{Activity in pCi/l}) \cdot (\text{half-life in years})$$

^e carb.SS is carbonate solid solution which includes calcite, magnesite, rhodochrosite, siderite, strontianite, and smithsonite components.

TABLE D.1-13

LEACHATE A AND LEACHATE B COMPOSITIONS
FOR INORGANICS AND RADIONUCLIDES IN
OPERABLE UNIT 1 - PIT 4

Element	Leachate A Concentration ^a	Constraint ^b	Leachate B Concentration ^a	Constraint ^b
pH	7.1 SU	NA ^c	6.88 SU	EQ3/6
Eh	0.2221 V	NA	+0.257 V	EQ3/6
Ammonia	81.2	ISL	81.2	ISL
Antimony	0.956	ISL	0.956	ISL
Arsenic	0.0025	ISL	0.0025	ISL
Barium	2.79	ISL	0.0441	barite
Beryllium	0.0809	ISL	7.12×10^{-4}	ISL
Boron	2.93	ISL	2.93	ISL
Cadmium	0.118	ISL	0.118	ISL
Cesium-137 ^d				
Chromium	2.22	ISL	0.0406	CrO ₂
Cobalt	0.338	ISL	0.338	ISL
Copper	0.643	ISL	0.643	ISL
Cyanide	0.0265	ISL	0.0265	ISL
Lead	0.002	ISL	0.002	ISL
Manganese	588.	ISL	5.98×10^{-3}	carb.SS ^e
Mercury	0.0002	ISL	8.8×10^{-9}	calomel
Molybdenum	0.629	ISL	0.629	ISL
Neptunium-237 ^d	5.11×10^{-7}	TCLP	1.45×10^{-9}	NpO ₂
Nickel	2.13	ISL	2.13	ISL
Nitrate	7.3	ISL	7.3	ISL
Plutonium-238 ^d	2.86×10^{-11}	mdl-ISL	2.86×10^{-11}	mdl-ISL
Plutonium-239 and 240	8.03×10^{-9}	mdl-ISL	1.01×10^{-10}	PuO ₂
Radium-226 ^d	9.4×10^{-9}	ISL	9.4×10^{-9}	ISL
Ruthenium-106 ^d				
Selenium	0.0025	ISL	0.0025	ISL

TABLE D.1-13
(Continued)

Element	Leachate A Concentration ^a	Constraint ^b	Leachate B Concentration ^a	Constraint ^b
Silver	1.16	ISL	0.056	Ag
Strontium-90 ^d	1.22×10^{-10}	ISL	7.31×10^{-13}	carb.SS
Technetium-99 ^d	2.07×10^{-5}	ISL	2.07×10^{-5}	ISL
Thallium				
Thorium-230 ^d	2.7×10^{-7}	ISL	2.1×10^{-9}	ThO ₂
Thorium-232 ^d	0.0087	mdl-ISL	2.1×10^{-9}	ThO ₂
Thorium-Total ^d	0.017	ISL	2.1×10^{-9}	thorianite
Tin	0.2	mdl-ISL	0.2	mdl-ISL
Uranium-234 ^d	0.0238	ISL	0.0238	ISL
Uranium-235 ^d	12.7	ISL	12.7	ISL
Uranium-238 ^d	1,280	ISL	1,280	ISL
Uranium-Total ^d	500	ISL	500	ISL
Vanadium	0.929	ISL	0.0145	carb.SS
Zinc	0.412	ISL	0.412	ISL

^a Element concentrations in milligrams per liter (ppm), pH in standard units (SU), and Eh in Volts (V). Blank spaces indicate that the constituent was not detected or analyzed in waste pit materials, therefore no leachate concentration was derived and the waste unit was assumed to have 0 source for that constituent.

^b Constraint on reported concentration is by EQ3/6 Geochemical Code (EQ3/6) Toxicity Characteristic Leaching Procedure (TCLP), in situ leachate (ISL), maximum detection limit (mdl), US EPA 70-year rule, or by solubility with respect to the indicated mineral phase.

^c NA = Not applicable.

^d Radioactive constituent. Formula for conversion of aqueous radioactivity to concentration of radionuclide in solution:

$$\text{mg/l} = 2.798 \times 10^{-15} \cdot (\text{gram formula wt}) \cdot (\text{Activity in pCi/l}) \cdot (\text{half-life in years})$$

^e carb.SS is carbonate solid solution which includes calcite, magnesite, rhodochrosite, siderite, strontianite, and smithsonite components.

TABLE D.1-14

LEACHATE A AND LEACHATE B COMPOSITIONS
FOR INORGANICS AND RADIONUCLIDES IN
OPERABLE UNIT 1 - PIT 5

Element	Leachate A Concentration ^a	Constraint ^b	Leachate B Concentration ^a	Constraint ^b
Antimony	0.1577	TCLP	0.1577	TCLP
Arsenic	0.00928	TCLP	0.00928	TCLP
Barium	0.628	TCLP	0.628	TCLP
Beryllium	0.0198	TCLP	0.0198	TCLP
Boron				
Cadmium	0.0094	TCLP	0.0094	TCLP
Cesium-137 ^c	1.04×10^{-9}	SW	1.04×10^{-9}	SW
Chromium	0.0243	TCLP	0.0243	TCLP
Cobalt	0.0748	TCLP	0.0748	TCLP
Copper	0.9478	TCLP	0.9478	TCLP
Cyanide	8.64×10^{-2}	70-year	8.64×10^{-2}	70-year
Lead	0.0177	TCLP	0.0177	TCLP
Manganese	2.4135	TCLP	2.4135	TCLP
Mercury	0.0218	TCLP	0.0218	TCLP
Molybdenum	1.15×10^{-2}	70-year	1.15×10^{-2}	70-year
Neptunium-237 ^c	5.0×10^{-7}	mdl-SW	5.0×10^{-7}	mdl-SW
Nickel	0.3025	TCLP	0.3025	TCLP
Plutonium-238 ^c	2.8×10^{-12}	mdl-SW	2.8×10^{-12}	mdl-SW
Plutonium-239 and 240 ^c	8×10^{-10}	mdl-SW	8×10^{-10}	mdl-SW
Radium-226 ^c	1.95×10^{-5}	70-year	1.95×10^{-5}	70-year
Ruthenium-106 ^c	1.27×10^{-11}	mdl-SW	1.27×10^{-11}	mdl-SW
Selenium	0.0021	SW	0.0021	SW
Silver	3.35×10^{-3}	mdl-SW	3.35×10^{-3}	mdl-SW
Strontium-90 ^c	2.9×10^{-10}	SW	2.9×10^{-10}	SW
Technetium-99 ^c	1.88×10^{-5}	SW	1.88×10^{-5}	SW
Thallium	5.5×10^{-4}	mdl-SW	5.5×10^{-4}	mdl-SW

TABLE D.1-14
(Continued)

Element	Leachate A Concentration ^a	Constraint ^b	Leachate B Concentration ^a	Constraint ^b
Thorium-230 ^c	5.14×10^{-9}	SW	5.14×10^{-9}	SW
Thorium-232 ^c	4.6×10^{-4}	mdl-SW	4.6×10^{-4}	mdl-SW
Tin	8.29	70-year	8.29	70-year
Uranium-234 ^c	6.79×10^{-5}	SW	6.79×10^{-5}	SW
Uranium-235 ^c	0.0089	SW	0.0089	SW
Uranium-238 ^c	1.2	SW	1.2	SW
Vanadium	1.4388	TCLP	1.4388	TCLP
Zinc	0.3338	TCLP	0.3338	TCLP

^a Element concentrations in milligrams per liter (ppm), pH in standard units (SU), and Eh in Volts (V). Blank spaces indicate that the constituent was not detected or analyzed in waste pit materials, therefore no leachate concentration was derived and the waste unit was assumed to have 0 source for that constituent.

^b Constraint on reported concentration is by Toxicity Characteristic Leaching Procedure (TCLP), surface water (SW), the maximum detection limit (mdl), US EPA 70-year rule (70-year), or by solubility with respect to the indicated mineral phase.

^c Radioactive constituent. Formula for conversion of aqueous radioactivity to concentration of radionuclide in solution:

$$\text{mg/l} = 2.798 \times 10^{-15} \cdot (\text{gram formula wt}) \cdot (\text{Activity in pCi/l}) \cdot (\text{half-life in years})$$

4787

TABLE D.1-15

LEACHATE A AND LEACHATE B COMPOSITIONS
FOR INORGANICS AND RADIONUCLIDES IN
OPERABLE UNIT 1 - PIT 6

Constituent	Leachate A Concentration ^a	Constraint ^b	Leachate B Concentration ^a	Constraint ^b
Antimony				
Arsenic	0.6316	TCLP	0.6316	TCLP
Barium	1.9559	TCLP	1.9559	TCLP
Beryllium	0.0204	TCLP	0.0204	TCLP
Boron				
Cadmium	9.5×10^{-4}	mdl-SW	9.5×10^{-4}	mdl-SW
Cesium-137 ^c	8.6×10^{-11}	mdl-SW	8.6×10^{-11}	mdl-SW
Chromium	2.2×10^{-3}	mdl-SW	2.2×10^{-3}	mdl-SW
Cobalt	4.75×10^{-3}	mdl-SW	4.75×10^{-3}	mdl-SW
Copper	0.006	mdl-SW	0.006	mdl-SW
Cyanide				
Lead	0.6914	TCLP	0.6914	TCLP
Manganese	2.008	TCLP	2.008	TCLP
Mercury				
Molybdenum				
Neptunium-237 ^c	1.06×10^{-5}	mdl-SW	1.06×10^{-5}	mdl-SW
Nickel	0.165	TCLP	0.165	TCLP
Plutonium-238 ^c	1.1×10^{-11}	mdl-SW	1.1×10^{-11}	mdl-SW
Plutonium-239 and 240 ^c	8×10^{-10}	mdl-SW	8×10^{-10}	mdl-SW
Radium-226 ^c	5.0×10^{-11}	mdl-SW	5.0×10^{-11}	mdl-SW
Ruthenium-106 ^c				
Selenium				
Silver	0.0667	TCLP	0.0667	TCLP
Strontium-90 ^c	7.0×10^{-12}	mdl-SW	7.0×10^{-12}	mdl-SW
Technetium-99 ^c	1.612×10^{-4}	SW	1.612×10^{-4}	SW
Thallium	0.7535	TCLP	0.7535	TCLP

TABLE D.1-15
(Continued)

4787

Constituent	Leachate A Concentration ^a	Constraint ^b	Leachate B Concentration ^a	Constraint ^b
Thorium-230 ^c	1.5×10^{-8}	SW	1.5×10^{-8}	SW
Thorium-232 ^c	4.6×10^{-4}	mdl-SW	4.6×10^{-4}	mdl-SW
Tin	1.30	70-year	1.30	70-year
Uranium-234 ^c	1.377E-05	SW	1.377×10^{-5}	SW
Uranium-235 ^c	4.62×10^{-3}	SW	4.62×10^{-3}	SW
Uranium-238 ^c	1.496	SW	1.496	SW
Vanadium	7.0×10^{-3}	mdl-SW	7.0×10^{-3}	mdl-SW
Zinc	1.7918	TCLP	1.7918	TCLP

^a Element concentrations in milligrams per liter (ppm), pH in standard units (SU), and Eh in Volts (V). Blank spaces indicate that the constituent was not detected or analyzed in waste pit materials, therefore no leachate concentration was derived and the waste unit was assumed to have 0 source for that constituent.

^b Constraint on reported concentration is Toxicity Characteristic Leaching Procedure (TCLP), surface water (SW), maximum detection limit (mdl), or by the US EPA 70-year rule (70-year).

^c Radioactive constituent. Formula for conversion of aqueous radioactivity to concentration of radionuclide in solution:

$$\text{mg/l} = 2.798 \times 10^{-15} \cdot (\text{gram formula wt}) \cdot (\text{Activity in pCi/l}) \cdot (\text{half-life in years})$$

0061

TABLE D.1-16

**LEACHATE A AND LEACHATE B COMPOSITIONS
FOR INORGANICS AND RADIONUCLIDES IN
OPERABLE UNIT 1 - BURN PIT**

Constituent	Leachate A Concentration ^a	Constraint ^b	Leachate B Concentration ^a	Constraint ^b
pH	12.16 SU	NA ^c	6.84SU	EQ3/6
Eh	+0.1377 V	NA	+0.259 V	EQ3/6
Antimony	0.103	ISL	0.103	ISL
Arsenic	0.0494	ISL	0.0494	ISL
Barium	8.3836	ISL	0.035	barite
Beryllium	0.0082	ISL	8.22×10^{-4}	BeO
Boron	2.12	ISL	2.12	ISL
Cadmium	0.0197	ISL	0.0197	ISL
Cesium-137 ^d				
Chromium	0.129	ISL	0.129	ISL
Cobalt	0.0377	ISL	0.0377	ISL
Copper	0.118	ISL	0.118	ISL
Cyanide	3.6	ISL	3.6	ISL
Lead	0.0981	ISL	0.0113	PbCO ₃
Manganese	2.96	ISL	0.0298	carb.SS ^e
Mercury	3.0×10^{-4}	ISL	2.4×10^{-8}	calomel
Molybdenum	1.05	ISL	1.05	ISL
Neptunium-237 ^d	3.9×10^{-7}	mdl-ISL	1.5×10^{-9}	NpO ₂
Nickel	0.299	ISL	0.299	ISL
Nitrate	5.7	ISL	5.7	ISL
Plutonium-238 ^d	2.86×10^{-11}	mdl-ISL	2.86×10^{-11}	mdl-ISL
Plutonium-239 and 240 ^d	8.03×10^{-9}	mdl-ISL	9.1×10^{-11}	PuO ₂
Radium-226 ^d	7.34×10^{-8}	ISL	7.34×10^{-8}	ISL
Ruthenium-106 ^d				
Selenium	0.0038	ISL	0.0038	ISL
Silver	0.107	ISL	2.06×10^{-3}	Ag

TABLE D.1-16
(Continued)

4782

Constituent	Leachate A Concentration ^a	Constraint ^b	Leachate B Concentration ^a	Constraint ^b
Strontium-90 ^d	1.8×10^{-11}	mdl-ISL	1.67×10^{-13}	carb.SS
Technetium-99 ^d	1.47×10^{-6}	TCLP	1.47×10^{-6}	TCLP
Thorium-230 ^d	1.13×10^{-7}	TCLP	2.12×10^{-9}	ThO ₂
Thorium-232S ^d	0.0110	TCLP	2.12×10^{-9}	ThO ₂
Thorium-Total ^d	0.0106	TCLP	2.12×10^{-9}	ThO ₂
Tin				
Uranium-234 ^d	1.46×10^{-4}	ISL	1.46×10^{-4}	ISL
Uranium-235 ^d	3.04×10^{-2}	ISL	3.04×10^{-2}	ISL
Uranium-238 ^d	2.95	ISL	2.95	ISL
Uranium-Total ^d	2.87	ISL	2.87	ISL
Vanadium	0.0743	ISL	0.0743	ISL
Zinc	0.253	ISL	0.0110	carb.SS

- ^a Element concentrations in milligrams per liter (ppm), pH in standard units (SU), and Eh in Volts (V). Blank spaces indicate that the constituent was not detected or analyzed in waste pit materials, therefore no leachate concentration was derived and the waste unit was assumed to have 0 source for that constituent.
- ^b Constraint on reported concentration is by EQ3/6 Geochemical Code (EQ3/6) Toxicity Characteristic Leaching Procedure (TCLP), in situ leachate (ISL), maximum detection limit (mdl), US EPA 70-year rule, or by solubility with respect to the indicated mineral phase.
- ^c NA = Not applicable.
- ^d Radioactive constituent. Formula for conversion of aqueous radioactivity to concentration of radionuclide in solution:

$$\text{mg/l} = 2.798 \times 10^{-15} \cdot (\text{gram formula wt}) \cdot (\text{Activity in pCi/l}) \cdot (\text{half-life in years})$$
- ^e carb.SS is carbonate solid solution which includes calcite, magnesite, rhodochrosite, siderite, strontianite, and smithsonite components.

4787

TABLE D.1-17

LEACHATE A AND LEACHATE B COMPOSITIONS
FOR INORGANICS AND RADIONUCLIDES IN
OPERABLE UNIT 1 - THE CLEARWELL

Constituent	Leachate A Concentration ^a	Constraint ^b	Leachate B Concentration ^a	Constraint ^b
Antimony	7.0×10^{-4}	mdl-SW	7.0×10^{-4}	mdl-SW
Arsenic	0.0042	SW	0.0042	SW
Barium	1.35×10^{-2}	mdl-SW	1.35×10^{-2}	mdl-SW
Beryllium	5.0×10^{-4}	mdl-SW	5.0×10^{-4}	mdl-SW
Boron				
Cadmium	9.5×10^{-4}	mdl-SW	9.5×10^{-4}	mdl-SW
Cesium-137 ^c	7.0×10^{-11}	mdl-SW	7.0×10^{-11}	mdl-SW
Chromium	0.0022	mdl-SW	0.0022	mdl-SW
Cobalt	4.75×10^{-3}	mdl-SW	4.75×10^{-3}	mdl-SW
Copper	0.019	SW	0.019	SW
Cyanide	0.087	SW	0.087	SW
Lead	5.5×10^{-4}	mdl-SW	5.5×10^{-4}	mdl-SW
Manganese	0.02	SW	0.02	SW
Mercury	1.0×10^{-4}	mdl-SW	1.0×10^{-4}	mdl-SW
Molybdenum	5.28	70-year	5.28	70-year
Nickel	9.0×10^{-3}	mdl-SW	9.0×10^{-3}	mdl-SW
Neptunium-237 ^c	4.51×10^{-4}	70-year	4.51×10^{-4}	70-year
Plutonium-238 ^c	1.1×10^{-11}	mdl-SW	1.1×10^{-11}	mdl-SW
Plutonium-239 and 240 ^c	4.8×10^{-9}	mdl-SW	4.8×10^{-9}	mdl-SW
Radium-226 ^c	1.1×10^{-9}	SW	1.1×10^{-9}	SW
Ruthenium-106 ^c				
Selenium	0.003	SW	0.003	SW
Silver	0.014	SW	0.014	SW
Strontium-90 ^c	1.06×10^{-11}	mdl-SW	1.06×10^{-11}	mdl-SW
Technetium-99 ^c	2.36×10^{-4}	SW	2.36×10^{-4}	SW
Thallium	5.5E-04	mdl-SW	5.5×10^{-4}	mdl-SW

TABLE D.1-17
(Continued)

4787

Constituent	Leachate A Concentration ^a	Constraint ^b	Leachate B Concentration ^a	Constraint ^b
Thorium-230 ^c	2.06E-08	SW	2.06×10^{-8}	SW
Thorium-232 ^c	4.6E-04	mdl-SW	4.6×10^{-4}	mdl-SW
Tin	2.62	70-year	2.62	70-year
Uranium-234 ^c	3.07×10^{-4}	SW	3.07×10^{-4}	SW
Uranium-235 ^c	0.056	SW	0.056	SW
Uranium-238 ^c	18.6	SW	18.6	SW
Vanadium	0.513	SW	0.513	SW
Zinc	0.047	SW	0.047	SW

^a Element concentrations in milligrams per liter (ppm), pH in standard units (SU), and Eh in Volts (V). Blank spaces indicate that the constituent was not detected or analyzed in waste pit materials, therefore no leachate concentration was derived and the waste unit was assumed to have 0 source for that constituent.

^b Constraint on reported concentration is by the maximum detection limit (mdl), surface water (SW), or by US EPA 70-year rule (70-year).

^c Radioactive constituent. Formula for conversion of aqueous radioactivity to aqueous concentration of radionuclide:

$$\text{mg/l} = 2.798 \times 10^{-15} \cdot (\text{gram formula wt.}) \cdot (\text{Activity in pCi/l}) \cdot (\text{half-life in years})$$

0065

TABLE D.1-18

ORGANIC LEACHATE CONCENTRATIONS IN OPERABLE UNIT 1 - PIT 1

Organic Constituents	Leachate Concentrations ^{a,b}	Constraint ^c
1,2,3,7,8-pentachlorodibenzofuran	6×10^{-4}	ISL
2,3,4,7,8-pentachlorodibenzofuran	9×10^{-4}	ISL
2,4,5-trichlorophenol		
4,4'-DDT	0.5	mdl-ISL
4-Nitroaniline		
4-Nitrophenol		
Acenaphthene		
Acenaphthylene		
Anthracene	40	mdl-ISL
Aroclor-1221	2.5	mdl-ISL
Aroclor-1242		
Aroclor-1248	3.1	ISL
Aroclor-1254	5	mdl-ISL
Aroclor-1260	5	mdl-ISL
Benzo(a)anthracene	40	mdl-ISL
Benzo(a)pyrene	40	mdl-ISL
Benzo(b)fluoranthene	40	mdl-ISL
Benzo(ghi)fluoranthene		
Benzo(ghi)perylene		
Benzo(k)fluoranthene	40	mdl-ISL
Chrysene	40	mdl-ISL
Dibenzo(a,h)anthracene		
Dichlorodifluoromethane	200	mdl-ISL
Fluoranthene	40	mdl-ISL
Fluorene		
Heptachlorodibenzofuran	1.7×10^{-3}	mdl-ISL
Heptachlorodibenzo-p-dioxin	3.4×10^{-3}	mdl-ISL
Hexachlorodibenzofuran	1.4×10^{-3}	mdl-ISL

TABLE D.1-18
(Continued)

4787

Organic Constituents	Leachate Concentrations ^{a,b}	Constraint ^c
Hexachlorodibenzo-p-dioxin	2.2 x 10 ⁻³	mdl-ISL
Indeno(1,2,3-cd)pyrene		
Naphthalene	40	mdl-ISL
Octachlorodibenzofuran	6 x 10 ⁻⁴	ISL
Octachlorodibenzo-p-dioxin	1.6 x 10 ⁻³	ISL
Pentachlorophenol		
Phenanthrene	40	mdl-ISL
Pyrene	40	mdl-ISL
Tetrachlorodibenzofuran	1.24 x 10 ⁻²	ISL
Tetrachloroethene	47	ISL
Vinyl Chloride		

^a Constituent concentrations in micrograms per liter.

^b Blank spaces indicate that the constituent was not detected or analyzed in waste pit materials, therefore no leachate concentration was derived and the waste unit was assumed to have 0 source for that constituent.

^c Constraint on reported concentration is by maximum detection limit (mdl), in situ leachate (ISL), CIS surface water (CISsw), or by the US EPA 70-year rule (70-year).

0067

4787

TABLE D.1-19

ORGANIC LEACHATE CONCENTRATIONS IN OPERABLE UNIT 1 - PIT 2

Organic Constituents	Leachate Concentrations ^{a,b}	Constraint ^c
1,2,3,7,8-pentachlorodibenzofuran	1×10^{-3}	mdl-ISL
2,3,4,7,8-pentachlorodibenzofuran		
2,4,5-trichlorophenol		
4,4'-DDT	1	mdl-ISL
4-Nitroaniline	50	mdl-ISL
4-Nitrophenol	50	mdl-ISL
Acenaphthene	12	ISL
Acenaphthylene	5	ISL
Anthracene	2	ISL
Aroclor-1221		
Aroclor-1242		
Aroclor-1248	0.5	mdl-ISL
Aroclor-1254	1	mdl-ISL
Aroclor-1260		
Benzo(a)anthracene	10	mdl-ISL
Benzo(a)pyrene	10	mdl-ISL
Benzo(b)fluoranthene	10	mdl-ISL
Benzo(ghi)fluoranthene	6.24×10^{-1}	70-year
Benzo(ghi)perylene	10	mdl-ISL
Benzo(k)fluoranthene	10	mdl-ISL
Chrysene	10	mdl-ISL
Dibenzo(a,h)anthracene	10	mdl-ISL
Dichlorodifluoromethane		
Fluoranthene	9	ISL
Fluorene	6	ISL
Heptachlorodibenzofuran	9×10^{-4}	ISL
Heptachlorodibenzo-p-dioxin	3.6×10^{-3}	mdl-ISL

See footnotes at end of table

TABLE D.1-19
(Continued)

4787

Organic Constituents	Leachate Concentrations ^{a,b}	Constraint ^c
Hexachlorodibenzofuran	1.7 x 10 ⁻³	mdl-ISL
Hexachlorodibenzo-p-dioxin	3 x 10 ⁻³	mdl-ISL
Indeno(1,2,3-cd)pyrene	10	mdl-ISL
Naphthalene	10	mdl-ISL
Octachlorodibenzofuran	7E-04	ISL
Octachlorodibenzo-p-dioxin	4.2E-03	ISL
Pentachlorophenol	50	mdl-ISL
Phenanthrene	10	mdl-ISL
Pyrene	7	ISL
Tetrachlorodibenzofuran		
Tetrachloroethene	5	mdl-ISL
Vinyl Chloride	160	ISL

^a Constituent concentrations in micrograms per liter.

^b Blank spaces indicate that the constituent was not detected or analyzed in waste pit materials, therefore no leachate concentration was derived and the waste unit was assumed to have 0 source for that constituent.

^c Constraint on reported concentration is by maximum detection limit (mdl), in situ leachate (ISL), CIS surface water (CISsw), or by the US EPA 70-year rule (70-year).

478

TABLE D.1-20

ORGANIC LEACHATE CONCENTRATIONS IN OPERABLE UNIT 1 - PIT 3

Organic Constituents	Leachate Concentrations ^{a,b}	Constraint ^c
1,2,3,7,8-pentachlorodibenzofuran		
2,3,4,7,8-pentachlorodibenzofuran		
2,4,5-trichlorophenol		
4,4'-DDT		
4-Nitroaniline		
4-Nitrophenol		
Acenaphthene		
Acenaphthylene	5.24×10^{-2}	70-year
Anthracene	10	mdl-ISL
Aroclor-1221		
Aroclor-1242		
Aroclor-1248	5	mdl-ISL
Aroclor-1254	10	mdl-ISL
Aroclor-1260		
Benzo(a)anthracene	10	mdl-ISL
Benzo(a)pyrene	10	mdl-ISL
Benzo(b)fluoranthene	10	mdl-ISL
Benzo(ghi)fluoranthene		
Benzo(ghi)perylene	10	mdl-ISL
Benzo(k)fluoranthene		
Chrysene	5	mdl-ISL
Dibenzo(a,h)anthracene		
Dichlorodifluoromethane		
Fluoranthene	10	mdl-ISL
Fluorene		
Heptachlorodibenzofuran	1.5×10^{-3}	ISL
Heptachlorodibenzo-p-dioxin	3.5×10^{-3}	ISL
Hexachlorodibenzofuran	1.7×10^{-3}	mdl-ISL

TABLE D.1-20
(Continued)

Organic Constituents	Leachate Concentrations ^{a,b}	Constraint ^c
Hexachlorodibenzo-p-dioxin	1.2×10^{-3}	mdl-ISL
Indeno(1,2,3-cd)pyrene	10	mdl-ISL
Naphthalene		
Octachlorodibenzofuran		
Octachlorodibenzo-p-dioxin		
Pentachlorophenol	7.09×10^{-1}	70-year
Phenanthrene	10	mdl-ISL
Pyrene	10	mdl-ISL
Tetrachlorodibenzofuran	5.7×10^{-4}	mdl-ISL
Tetrachloroethene	2.0	ISL
Vinyl Chloride		

^a Constituent concentrations in micrograms per liter.

^b Blank spaces indicate that the constituent was not detected or analyzed in waste pit materials, therefore no leachate concentration was derived and the waste unit was assumed to have 0 source for that constituent.

^c Constraint on reported concentration is by maximum detection limit (mdl), in situ leachate (ISL), CIS surface water (CISsw), or by the US EPA 70-year rule (70-year).

0071

4787

TABLE D.1-21

ORGANIC LEACHATE CONCENTRATIONS IN OPERABLE UNIT 1 - PIT 4

Organic Constituents	Leachate Concentrations ^{a,b}	Constraint ^c
1,2,3,7,8-pentachlorodibenzofuran	1×10^{-3}	mdl-ISL
2,3,4,7,8-pentachlorodibenzofuran	1.1×10^{-3}	mdl-ISL
2,4,5-trichlorophenol		
4,4'-DDT		
4-Nitroaniline		
4-Nitrophenol	10	mdl-ISL
Acenaphthene	12	ISL
Acenaphthylene		
Anthracene	17	ISL
Aroclor-1221		
Aroclor-1242	50	mdl-ISL
Aroclor-1248	50	mdl-ISL
Aroclor-1254	100	mdl-ISL
Aroclor-1260		
Benzo(a)anthracene	10	mdl-ISL
Benzo(a)pyrene	10	mdl-ISL
Benzo(b)fluoranthene	10	mdl-ISL
Benzo(ghi)fluoranthene		
Benzo(ghi)perylene	10	mdl-ISL
Benzo(k)fluoranthene	10	mdl-ISL
Chrysene	10	mdl-ISL
Dibenzo(a,h)anthracene	10	mdl-ISL
Dichlorodifluoromethane		
Fluoranthene	2	ISL
Fluorene	9	ISL
Heptachlorodibenzofuran	2.4×10^{-3}	mdl-ISL
Heptachlorodibenzo-p-dioxin	9.4×10^{-4}	mdl-ISL
Hexachlorodibenzofuran	1.2×10^{-3}	mdl-ISL

0072

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TABLE D.1-21
(Continued)

4787

Organic Constituents	Leachate Concentrations ^{a,b}	Constraint ^c
Hexachlorodibenzo-p-dioxin	7.5×10^{-4}	mdl-ISL
Indeno(1,2,3-cd)pyrene	10	mdl-ISL
Naphthalene	16	ISL
Octachlorodibenzofuran	9×10^{-4}	mdl-ISL
Octachlorodibenzo-p-dioxin	1.2×10^{-3}	mdl-ISL
Pentachlorophenol		
Phenanthrene	10	mdl-ISL
Pyrene	10	mdl-ISL
Tetrachlorodibenzofuran	1.7×10^{-3}	mdl-ISL
Tetrachloroethene	140	ISL
Vinyl Chloride	6.0	ISL

^a Constituent concentrations in micrograms per liter.

^b Blank spaces indicate that the constituent was not detected or analyzed in waste pit materials, therefore no leachate concentration was derived and the waste unit was assumed to have 0 source for that constituent.

^c Constraint on reported concentration is by maximum detection limit (mdl), in situ leachate (ISL), CIS surface water (CISsw), or by the US EPA 70-year rule (70-year).

4787

TABLE D.1-22

ORGANIC LEACHATE CONCENTRATIONS IN OPERABLE UNIT 1 - PIT 5

Organic Constituents	Leachate Concentrations ^{a,b}	Constraint ^c
1,2,3,7,8-pentachlorodibenzofuran		
2,3,4,7,8-pentachlorodibenzofuran		
2,4,5-trichlorophenol		
4,4'-DDT		
4-Nitroaniline		
4-Nitrophenol		
Acenaphthene		
Acenaphthylene		
Anthracene		
Aroclor-1221		
Aroclor-1242		
Aroclor-1248	0.5	mdl-CISsw
Aroclor-1254	1	mdl-CISsw
Aroclor-1260		
Benzo(a)anthracene		
Benzo(a)pyrene		
Benzo(b)fluoranthene		
Benzo(ghi)fluoranthene		
Benzo(ghi)perylene		
Benzo(k)fluoranthene		
Chrysene		
Dibenzo(a,h)anthracene		
Dichlorodifluoromethane		
Fluoranthene		
Fluorene		
Heptachlorodibenzofuran		
Heptachlorodibenzo-p-dioxin		
Hexachlorodibenzofuran		

TABLE D.1-22
(Continued)

4787

Organic Constituents	Leachate Concentrations ^{a,b}	Constraint ^c
Hexachlorodibenzo-p-dioxin		
Indeno(1,2,3-cd)pyrene		
Naphthalene		
Octachlorodibenzofuran		
Octachlorodibenzo-p-dioxin		
Pentachlorophenol		
Phenanthrene		
Pyrene		
Tetrachlorodibenzofuran		
Tetrachloroethene		
Vinyl Chloride		

- ^a Constituent concentrations in micrograms per liter.
- ^b Blank spaces indicate that the constituent was not detected or analyzed in waste pit materials, therefore no leachate concentration was derived and the waste unit was assumed to have 0 source for that constituent.
- ^c Constraint on reported concentration is by maximum detection limit (mdl), in situ leachate (ISL), CIS surface water (CISsw), or by the US EPA 70-year rule (70-year).

4787

TABLE D.1-23

ORGANIC LEACHATE CONCENTRATIONS IN OPERABLE UNIT 1 - PIT 6

Organic Constituents	Leachate Concentrations ^{a,b}	Constraint ^c
1,2,3,7,8-pentachlorodibenzofuran		
2,3,4,7,8-pentachlorodibenzofuran		
2,4,5-trichlorophenol		
4,4'-DDT		
4-Nitroaniline		
4-Nitrophenol		
Acenaphthene		
Acenaphthylene		
Anthracene		
Aroclor-1221		
Aroclor-1242		
Aroclor-1248		
Aroclor-1254	0.5	mdl-CISsw
Aroclor-1260		
Benzo(a)anthracene		
Benzo(a)pyrene		
Benzo(b)fluoranthene		
Benzo(ghi)fluoranthene		
Benzo(ghi)perylene		
See footnotes at end of table		
Benzo(k)fluoranthene		
Chrysene		
Dibenzo(a,h)anthracene		
Dichlorodifluoromethane		
Fluoranthene		
Fluorene		
Heptachlorodibenzofuran		
Heptachlorodibenzo-p-dioxin		

TABLE D.1-23
(Continued)

4787

Organic Constituents	Leachate Concentrations ^{a,b}	Constraint ^c
Hexachlorodibenzofuran		
Hexachlorodibenzo-p-dioxin		
Indeno(1,2,3-cd)pyrene		
Naphthalene		
Octachlorodibenzofuran		
Octachlorodibenzo-p-dioxin		
Pentachlorophenol		
Phenanthrene		
Pyrene		
Tetrachlorodibenzofuran		
Tetrachloroethene	6	CISsw
Vinyl Chloride		

^a Constituent concentrations in micrograms per liter.

^b Blank spaces indicate that the constituent was not detected or analyzed in waste pit materials, therefore no leachate concentration was derived and the waste unit was assumed to have 0 source for that constituent.

^c Constraint on reported concentration is by maximum detection limit (mdl), in situ leachate (ISL), CIS surface water (CISsw), or by the US EPA 70-year rule (70-year).

0077

4787

TABLE D.1-24

ORGANIC LEACHATE CONCENTRATIONS IN OPERABLE UNIT 1 - BURN PIT

Organic Constituents	Leachate Concentrations ^{a,b}	Constraint ^c
1,2,3,7,8-pentachlorodibenzofuran		
2,3,4,7,8-pentachlorodibenzofuran		
2,4,5-trichlorophenol		
4,4'-DDT		
4-Nitroaniline		
4-Nitrophenol		
Acenaphthene	40	mdl-ISL
Acenaphthylene		
Anthracene	40	mdl-ISL
Aroclor-1221		
Aroclor-1242		
Aroclor-1248		
Aroclor-1254	20	mdl-ISL
Aroclor-1260		
Benzo(a)anthracene	40	mdl-ISL
Benzo(a)pyrene	40	mdl-ISL
Benzo(b)fluoranthene	40	mdl-ISL
Benzo(ghi)fluoranthene		
Benzo(ghi)perylene	40	mdl-ISL
Benzo(k)fluoranthene	40	mdl-ISL
Chrysene	40	mdl-ISL
Dibenzo(a,h)anthracene		
Dichlorodifluoromethane		
Fluoranthene	40	mdl-ISL
Fluorene	40	mdl-ISL
Heptachlorodibenzofuran		
Heptachlorodibenzo-p-dioxin	7.2 x 10 ⁻⁴	mdl-ISL
Hexachlorodibenzofuran		

0078

TABLE D.1-24
(Continued)

4787

Organic Constituents	Leachate Concentrations ^{a,b}	Constraint ^c
Hexachlorodibenzo-p-dioxin		
Indeno(1,2,3-cd)pyrene	40	mdl-ISL
Naphthalene	12	ISL
Octachlorodibenzofuran	1.1×10^{-3}	mdl-ISL
Octachlorodibenzo-p-dioxin	1.8×10^{-3}	mdl-ISL
Pentachlorophenol	200	mdl-ISL
Phenanthrene	40	mdl-ISL
Pyrene	40	mdl-ISL
Tetrachlorodibenzofuran		
Tetrachloroethene	2	ISL
Vinyl Chloride	1,000	mdl-ISL

^a Constituent concentrations in micrograms per liter.

^b Blank spaces indicate that the constituent was not detected or analyzed in waste pit materials, therefore no leachate concentration was derived and the waste unit was assumed to have 0 source for that constituent.

^c Constraint on reported concentration is by maximum detection limit (mdl), in situ leachate (ISL), CIS surface water (CISsw), or by the US EPA 70-year rule (70-year).

TABLE D.1-25

ORGANIC LEACHATE CONCENTRATIONS IN OPERABLE UNIT 1 - CLEARWELL

Organic Constituents	Leachate Concentrations ^{a,b}	Constraint ^c
1,2,3,7,8-pentachlorodibenzofuran		
2,3,4,7,8-pentachlorodibenzofuran		
2,4,5-trichlorophenol		
4,4'-DDT	8.96×10^{-1}	70-year
4-Nitroaniline		
4-Nitrophenol		
Acenaphthene		
Acenaphthylene		
Anthracene	6.5×10^{-2}	70-year
Aroclor-1221		
Aroclor-1242	1	mdl-CISsw
Aroclor-1248	1	mdl-CISsw
Aroclor-1254	2	mdl-CISsw
Aroclor-1260		
Benzo(a)anthracene	1.29×10^{-1}	70-year
Benzo(a)pyrene	9.68×10^{-2}	70-year
Benzo(b)fluoranthene	1.03×10^{-1}	70-year
Benzo(ghi)fluoranthene		
Benzo(ghi)perylene	3.32×10^{-2}	70-year
Benzo(k)fluoranthene	1.08×10^{-1}	70-year
Chrysene	1.45×10^{-1}	70-year
Dibenzo(a,h)anthracene		
Dichlorodifluoromethane		
Fluoranthene	4.48×10^{-1}	70-year
Fluorene	4.05×10^{-2}	70-year
Heptachlorodibenzofuran		
Heptachlorodibenzo-p-dioxin		
Hexachlorodibenzofuran		

TABLE D.1-25
(Continued)

4787

Organic Constituents	Leachate Concentrations ^{a,b}	Constraint ^c
Hexachlorodibenzo-p-dioxin		
Indeno(1,2,3-cd)pyrene	3.90×10^{-2}	70-year
Naphthalene		
Octachlorodibenzofuran		
Octachlorodibenzo-p-dioxin		
Pentachlorophenol		
Phenanthrene	2.58×10^{-1}	70-year
Pyrene	2.02×10^{-1}	70-year
Tetrachlorodibenzofuran		
Tetrachloroethene		
Vinyl Chloride		

^a Constituent concentrations in micrograms per liter.

^b Blank spaces indicate that the constituent was not detected or analyzed in waste pit materials, therefore no leachate concentration was derived and the waste unit was assumed to have 0 source for that constituent.

^c Constraint on reported concentration is by maximum detection limit (mdl), in situ leachate (ISL), CIS surface water (CISsw), or by the US EPA 70-year rule (70-year).

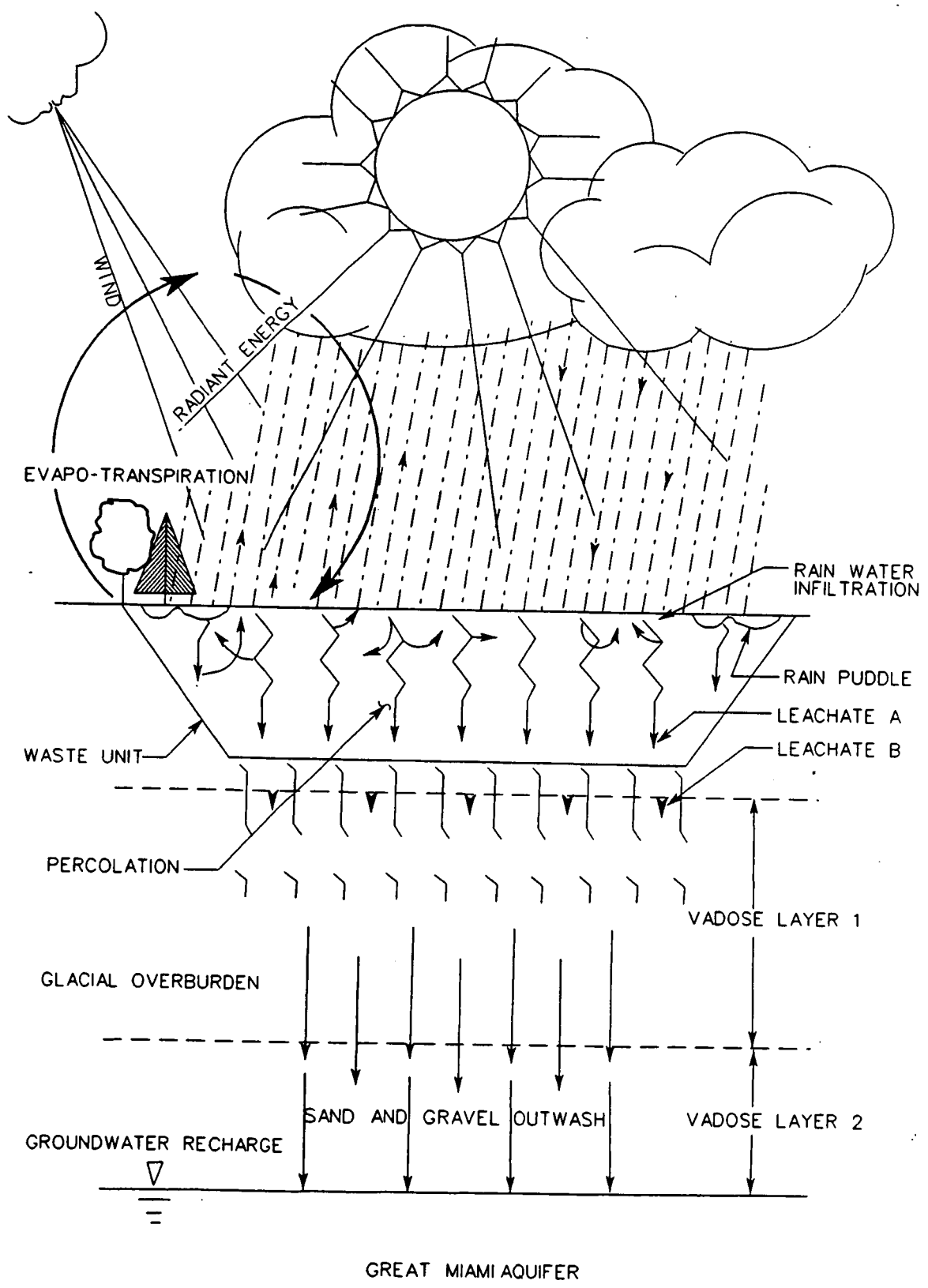


FIGURE D.1-1. CONCEPTUAL VADOSE ZONE MODEL

SKX02064-A/OUT/FAIR
SKX02064.DGN/08/06/93/RM

4787

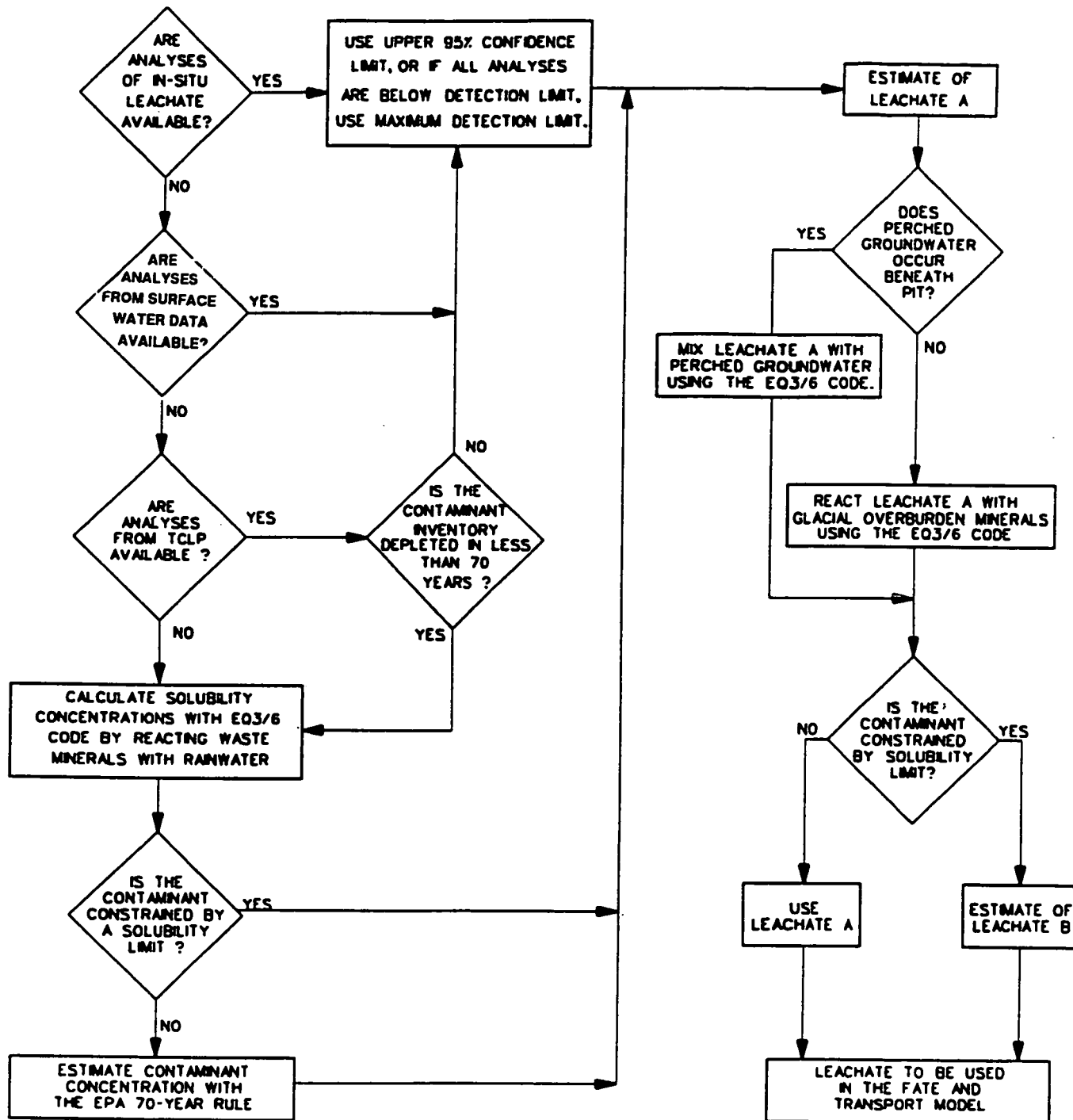


FIGURE D.1-2. ESTIMATING LEACHATE FOR RADIONUCLIDES AND INORGANICS

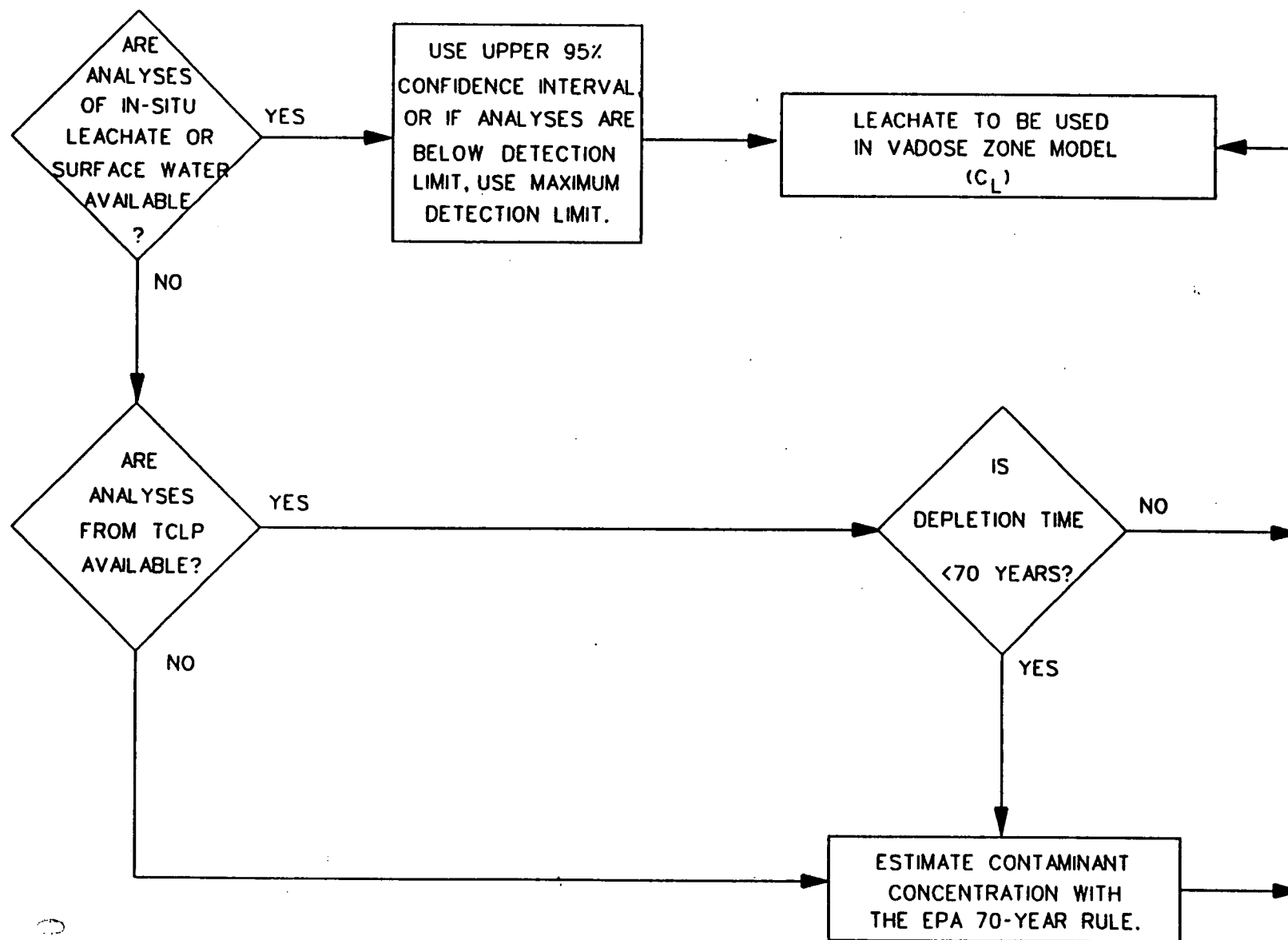


FIGURE D.1-3. ESTIMATING LEACHATE FOR ORGANICS

D.2.0 SURFACE WATER MODELING

4787

D.2.1 INTRODUCTION

The modeling approach used to estimate contaminant concentrations in surface water and sediment resulting from transport by surface water runoff from Operable Unit 1 is described in this section. Modeling the transport of soil by runoff requires characterization of the contaminants in the initial soil or waste source term. Based on the runoff scenarios selected, runoff and partitioning models were used to quantify the migration of contaminants from the waste source term to stream sediment and surface water from erosion by runoff effluent.

Contaminants in surface soil can be released from source areas and transported to surface water via precipitation runoff. During a rainfall event, some amount of the rainwater infiltrates the soil surface and some runs off the surface as shown in Figure D.2-1. The amount of runoff depends on soil type, vegetative cover, the amount of moisture already present in the soil, and the intensity and duration of rainfall, slope length, and slope steepness.

Contaminants in the surface soil can be transported via runoff either in the dissolved phase or adsorbed to soil particles. The less soluble a contaminant is in water, the more likely it will be adsorbed to soil particles. Because the water solubility of contaminants in Operable Unit 1 can vary widely, transport is modeled for both dissolved-phase and adsorbed-phase contaminants.

Because Paddys Run is in direct contact with the Great Miami Aquifer over a portion of its course, this section also describes the use of the surface water modeling results to define source terms for the aquifer modeling performed in Section D.3.7.

D.2.2 CONCEPTUAL MODEL

Sources that are potentially vulnerable to erosion by surface water flowing across Operable Unit 1 are the contaminated surface soils within Operable Unit 1. These soils can contribute to off-property contamination of surface water and sediment. Because Paddys Run would receive any runoff from these soils and the area of Operable Unit 1 is relatively small, these soils are treated as one large source when assessing the impact of Operable Unit 1 on water quality in Paddys Run and the Great Miami River. Surface soil contaminant concentrations used in the surface water assessment are the upper 95 percent confidence interval on the means of the surface soil concentrations reported in each individual sample from the CIS and RI/FS surface soil data bases for Operable Unit 1 (Table D.2-1). For modeling purposes, compounds which were not detected (ND designation in Table D.2-1) in any available sample were assigned a value of zero in assigning source concentrations. For surface water modeling purposes, all of the waste areas for Operable Unit 1 were treated as a single source.

Paddys Run is an intermittent stream that begins north of the site and flows southward along the western edge of the Fernald Environmental Management Project (FEMP). Prior to the completion of Removal Action No. 2, natural drainage from Operable Unit 1 flowed to Paddys Run (Figure D.2-2). Paddys Run flows into the Great Miami River 1.5 miles south of the FEMP. Removal Action No. 2 was undertaken to minimize future runoff from reaching Paddys Run. Field work was completed for the implementation of this removal action in July 1992.

The direction of surface water flow is determined by examining the topographic map of the Operable Unit 1 Study Area presented in Figure D.2-2. Figure D.2-2 also provides information on the slope of the ground surface in the Operable Unit 1 Study Area, and the distance to the nearest receiving stream (Paddys Run).

Local meteorological data are used to obtain estimates of the amount and duration of rainfall at the site. The volume of surface water runoff flowing to Paddys Run is estimated in the surface water runoff modeling using the SCS curve method. The surface runoff modeling was based on a single storm event (6.35 cm in 24 hours; Hershfield 1961). For surface flow modeling purposes, the flow rate in Paddys Run of 410 m³/hr generated by the storm is used.

Information on the soil types present is obtained from the soil borings in Operable Unit 1 using the U.S. Soil Conservation Service designations, which are presented in detail in Section 3.0 of this RI report. The types and areal density of vegetation in Operable Unit 1 are provided by aerial photos, site reconnaissance and interviews with personnel familiar with the Operable Unit 1 Study Area.

Many of the organic contaminants of potential concern (CPC) found at Superfund sites are nonpolar, hydrophobic substances. Such substances tend to sorb to soils and migrate from the site more slowly than will polar substances. Estimates of the amounts of hydrophobic substances released in site runoff were calculated using the Modified Universal Soil Loss Equation (MUSLE). Additional equations were used to describe contaminant partitioning between soil and water in the receiving water body. These partitioning models provided an estimate of the contaminant concentration in surface water runoff and in the soil that is carried with the runoff and deposited in the sediments of receiving surface water bodies (Haith 1980; Mills et al. 1982). Contaminant concentrations in Paddys Run are calculated as simple dilutions of dissolved concentrations in surface water runoff. Contaminant concentrations in the Great Miami River are calculated as simple dilutions of dissolved concentrations in Paddys Run.

D.2.3 SURFACE WATER MODEL APPLICATION

Two soil loss models obtained from the EPA "Superfund Exposure Assessment Manual" (EPA 1988b), the Universal Soil Loss Equation (USLE) and MUSLE, were considered as tools to quantify soil migration. The USLE model takes the same form as MUSLE, except the USLE uses an area-

dependent method to determine runoff, while MUSLE employs event-specific runoff volume and flow rate variables. The MUSLE model was chosen over the USLE model to facilitate evaluation of an event-specific worst-case conservative scenario as opposed to a yearly average contaminant transport scenario. The MUSLE model calculates the total mass of soil transported by surface water in a single rainfall event using event-specific runoff volume, storm duration, and flow rate variables.

Additional equations were used to describe contaminant partitioning between soil and water in the runoff flow. These partitioning equations provide an estimate of the contaminant concentration dissolved in water runoff and adsorbed to the soil that is carried with the runoff and deposited in the sediment of receiving surface water bodies (Haith 1980; Mills et al. 1982, Mockus 1972). The volume of runoff is also estimated to determine both the amount that stream flow may be increased by a runoff event, and to estimate dissolved contaminant loading. The depth of runoff is calculated as a function of the depth of rainfall and a soil water retention factor. In effect, the amount of water retained by the soil is subtracted from the total amount of rainfall and the remainder is available as runoff flow. A certain amount of rainfall, depending on soil conditions, is required before any runoff occurs. The dissolved contaminant concentration in the Great Miami River is estimated as a simple dilution of runoff concentration by the flow in the Great Miami River.

D.2.3.1 Model Assumptions

These models are based on the following assumptions:

- Constituents adsorbed to soils in runoff remain adsorbed in the stream sediments.
- Constituents dissolved in runoff water remain in the water column in the receiving stream.

D.2.3.2 Calculation of Soil Loss from Runoff

The soil loss model, MUSLE, obtained from the EPA "Superfund Exposure Assessment Manual," (EPA 1988b), is used to model the amount of contaminated soil migrating to Paddys Run from erosion by precipitation runoff. The MUSLE model is based on the following equation.

$$Y(s)_E = (CF)[(V_r)(q_p)]^{0.56}(K)(LS)(C)(P)$$

The MUSLE employs event-specific runoff volume and flow rate variables:

$Y(s)_E$	=	Soil loss in runoff (metric tons per event)
CF	=	Conversion factor (11.8 for metric units)
V_r	=	Volume of runoff (m^3)
q_p	=	Peak runoff flow rate (m^3/s)
K	=	Soil erodibility factor (metric tons/ha/unit erosion potential)
LS	=	Product of slope length factor and slope steepness factor (0.25, unitless)
C	=	Cover factor (unitless)
P	=	Erosion control practice factor (unitless)

Intermediate parameters V_r and q_p are calculated by:

$$V_r = (100)(A)(Q_r)$$

where

$$Q_r = (R_t - 0.2S_w)^2 / (R_t + 0.8S_w)$$

and

$$S_w = (2.54)[(1000/CN) - 10]$$

q_p is calculated by

$$q_p = [(0.028)(A)(R_t)(Q_r)] / [(T_r)(R_t - 0.2 S_w)]$$

For the calculations of V_r and q_p :

A	=	Contaminated surface area (ha)
Q_r	=	Depth of runoff (cm)
R_t	=	Depth of rainfall event (cm)
S_w	=	Soil water retention factor (cm)
CN	=	SCS runoff curve number (unitless)
T_r	=	Rainfall duration (hours)

Table D.2-2 lists the parameter values used in the Operable Unit 1 surface water runoff assessment. Based on these values, the calculated soil loss $Y(s)_E$ is 0.53 metric tons per event for the Operable Unit 1 area.

D.2.3.3 Calculation of Contaminant Partitioning and Loading

The portion of contaminant from the eroded soil that remains with the sediment or is dissolved in the water is estimated using the following equations, respectively:

$$S_s = [1 / (1 + \theta_c / (K_d \cdot \rho))] (C_i)(\rho)(A')(CF)$$

and

$$M_s = [1 / (1 + (K_d \cdot \rho) / \theta_c)] (C_i)(\rho)(A')(CF)$$

where

S_s	=	Available quantity of contaminant absorbed to sediment (g)
M_s	=	Available quantity of contaminant dissolved in water (g)
θ_c	=	Available water capacity in top cm of soil (unitless)
K_d	=	Chemical-specific sorption partition coefficient (cm^3/g)
ρ	=	Bulk soil density (g/cm^3)
C_i	=	Concentration of contaminant in soil (mg/kg)

A' = Contaminated volume (ha-cm)
 CF = Conversion factor (100 kg/mg-cm²/ha)

The mass of absorbed contaminant in the source area is:

$$PX_i = [Y(s)_E / 100(\rho)(A')](S_s)$$

The contaminant concentration in sediment of the receiving water body is:

$$C_s = PX_i / Y(s)_E$$

where

C_s = Concentration of contaminant in sediment (mg/kg)
 PX_i = Absorbed quantity of contaminant (g)

The mass of dissolved contaminant from the source area is:

$$PQ_i = M_s(Q_r/R_i)$$

where

PQ_i = Dissolved substance available per event (g)

The contaminant concentration in the runoff effluent is:

$$C_e = PQ_i / V_r$$

where

PQ_i = Dissolved substance available per event (g)
 C_e = Concentration of contaminant in runoff (mg/l)
 V_r = Volume of runoff (m³)

The dissolved contaminant concentration in the receiving water body (Paddys Run) downstream is:

$$C_w = (C_e)(Q_e) / (Q_i + Q_e)$$

where

C_w = Concentration of contaminant in water downstream (mg/L)
 Q_e = Average runoff effluent flow rate (V_r/T_r; m³/hr)
 Q_i = Flow rate of receiving water body (m³/hr)

The dissolved contaminant concentration in the Great Miami River is estimated by:

$$C_{gmr} = (C_w)(Q_i) / (Q_{gmr} + Q_i)$$

where

C_{gmr} = Concentration of contaminant in the Great Miami River (mg/L)
Q_{gmr} = Flow rate of the Great Miami River (m³/hr)

An average flow rate of 340,000 m³/hr was used for the Great Miami River based on previous studies (DOE 1993a). For determining the concentrations in the Great Miami River, it was conservatively assumed that flow and contaminant mass in Paddys Run empties into the Great Miami River.

D.2.4 RESULTS OF SURFACE WATER RUNOFF MODELING

Results of the surface water modeling are presented in Table D.2-3. These results show pounds per day of contaminant flowing in Paddys Run, Paddys Run sediment concentration, Paddys Run concentration, and Great Miami River concentrations. These results show ranges in Paddys Run concentrations from a minimum for cesium-137 of 2.680E-14 mg/L to a maximum for uranium-238 of 2.55E-01 mg/L. Since a constant dilution factor converts Paddys Run concentration to Great Miami River concentration (see discussion above), the constituents maintain the same relative concentrations in the Great Miami River although they are approximately 3 orders of magnitude lower. As shown in Table D.2-3 Paddys Run sediment is predicted to have 7.24×10^2 mg/kg concentration of uranium-238 (the maximum constituent) and less of the remaining constituents depending on the distribution coefficient (K_d).

D.2.4.1 Comparison of Modeled Results to Measured Concentrations

Modeled concentrations in Paddys Run surface water are compared to measured concentrations for several constituents in Table D.2-4. Actual surface water concentrations are expected to vary over time, depending on the current rainfall pattern. Also, a direct comparison is limited by the scope of the surface water runoff model; only surface soil within the Operable Unit 1 Study Area are accounted for, while actual concentrations in Paddys Run result from runoff from the entire stream drainage area including upstream contributions.

Measured and modeled concentrations are consistent for the following constituents: thorium-230, thorium-232, cadmium, chromium, copper, nickel, and silver. In most of these cases, both modeled concentrations and measured concentrations in surface water samples are less than the reported detection limits for surface water samples. The modeled concentration for lead is approximately 2 orders of magnitude less than measured concentrations. Modeled activities for uranium-234 and uranium-238 are approximately 1 order of magnitude higher than measured activities. For lead, the modeled concentration is lower than the measured concentration which could be due to sources other Operable Unit 1.

The fact that modeled results for several constituents are consistent with measured data suggests that the surface water runoff model is producing reasonable estimates of surface water runoff from

Operable Unit 1. Comparison to measured data, however, is limited based on the discussion presented above.

D.2.5 UNCERTAINTIES IN THE SURFACE WATER MODEL

The surface water model is a mathematical tool which simplifies the actual situation. Uncertainties in the output from the model are introduced from three primary sources:

- **Input Variable Uncertainty:** The accuracy of the model prediction is highly dependent on the accuracy of the input variables. Input variables such as the SCS runoff curve number, rainfall and runoff factor, soil erodibility factor, slope length and steepness factor, cover factor, etc. are approximate numbers representing the physical characteristics of a given site. The chemical-specific K_d values, used to calculate the fraction of contaminants sorbed to soil particles, are another source of uncertainty.
- **Modeling Uncertainty:** Any mathematical model representing a physical process tends to be simplified to making approximations and assumptions. The uncertainties in model predictions will increase with increased simplification of the model. Several portions of the surface water model equations consist of empirical equations which are approximations of actual physical processes.
- **Scenario Uncertainty:** The assumption that the whole area of Operable Unit 1 acts as a point source of contamination, and the use of area-weighted average concentrations for the site will introduce some uncertainty in the model predictions. Another source of uncertainty and conservatism is the assumption of immediate failure of the liners for Pits 1, 2, and 4.

D.2.6 PADDYS RUN LOADING TO THE GREAT MIAMI AQUIFER

Because Paddys Run lies directly in contact with the Great Miami Aquifer over a portion of its course, a contaminant migration pathway exists into the aquifer through its streambed. Migration of contaminants in surface runoff to Paddys Run from the surface soil in the Operable Unit 1 waste areas and from Paddys Run to the Great Miami Aquifer has been designated the surface water to groundwater pathway. As discussed below, a screening procedure and method of deriving the contaminant loading to the Great Miami Aquifer from Paddys Run based on the results of the surface water modeling were developed to account for this pathway in the groundwater fate and transport modeling (Section D.3.0).

D.2.6.1 Paddys Run Screening

Figure D.2-4 presents the surface water to groundwater pathway transport modeling diagram which shows the different steps that are involved in developing the source terms for CPCs and the modeling process. CPCs that follow the surface water pathway to the Great Miami Aquifer are first screened to remove constituents that pose insignificant risk. This screening is performed by taking the contaminant concentration in the runoff effluent (C_e) from MUSLE, and applying a Great Miami Aquifer dilution factor to this concentration to determine a theoretical Great Miami Aquifer

concentration. This theoretical Great Miami Aquifer concentration was then compared to 10^{-7} risk based concentrations for carcinogens or 0.1 Hazard Quotient concentrations for non-carcinogens. These screening concentrations are derived by dividing the 10^{-6} risk based concentrations or Hazard Quotient of 1 concentrations for tap water (EPA 1993) by 10. If theoretical Great Miami Aquifer concentrations are below the screening concentrations then the constituent is screened out and is not modeled in the aquifer (Table D.2-5).

The Great Miami Aquifer dilution factor is determined by a mixing equation based on the direct infiltration of 30 percent of the runoff effluent volume, prior to dilution in Paddys Run, into the Great Miami Aquifer as described below.

The predicted theoretical diluted concentration in the Great Miami Aquifer based on mixing of runoff effluent volume with the volume of water in the Great Miami Aquifer flowing in 1 Sandia Waste Isolation Flow and Transport (SWIFT) cell is:

$$C_{GMA} = (C_e)(V_{rcell}) / (V_{rcell} + V_{cell})$$

where

- C_{GMA} = Predicted theoretical diluted concentration in the Great Miami Aquifer (mg/L)
 V_{cell} = Volume of groundwater in layer 1 of the Great Miami Aquifer in the average thickness Sandia Waste Isolation Flow and Transport (SWIFT) cell block along Paddys Run in close proximity to Operable Unit 1 (ft³)
 V_{rcell} = Runoff volume per SWIFT cell (ft³/cell)

The volume of water flowing through the SWIFT cell is calculated from:

$$V_{cell} = (W_{PR})(L_{cell})(T)(\phi_{GMA})$$

where

- W_{PR} = Average width of Paddys Run for modeling purposes (25 ft)
 L_{cell} = Length of SWIFT cell (125 feet)
 T = Thickness of layer 1 of the Great Miami Aquifer in SWIFT cell (34.28 ft)
 ϕ_{GMA} = Porosity of the Great Miami Aquifer (25 percent)

The V_{cell} is calculated to be $2.6778E+04$ ft³ per 24-hour storm event.

The runoff effluent volume per SWIFT cell along Paddys Run is estimated from:

$$V_{\text{r cell}} = (V_r)(I)/(N)$$

where

- V_r = Runoff volume from MUSLE based on 24-hour storm event (ft³/day)
- I = Percentage of runoff effluent volume assumed to infiltrate to the Great Miami Aquifer through Paddys Run (30 percent, DOE, 1993b)
- N = Number of SWIFT cells along Paddys Run between Operable Unit 1 and the FEMP property boundary (83 cells)

The $V_{\text{r cell}}$ is estimated as 274.01 ft³/day-cell.

Table D.2-5 shows the results of the Paddys Run dilution screening of CPCs. Constituents requiring modeling with SWIFT are arsenic, technetium-99, uranium-234, and uranium-238. These contaminants represent the surface water pathway source terms for the Great Miami Aquifer modeling performed in Section D.3.7.

Table D.2-6 presents a comparison of the maximum concentration in selected wells located along Paddys Run (see Figure D.2-3) and the predicted theoretical diluted concentration in the Great Miami Aquifer. Wells 2009, 2108, 2004 and 2107 were selected based on their close proximity to Paddys Run. As shown on Table D.2-6, the predicted aquifer concentrations for the constituents of concern requiring further modeling are generally within the same order of magnitude as measured concentrations in the wells with the exception of arsenic. The good correlation between measured and predicted concentrations suggests that the screening procedure produces reasonable estimates of diluted aquifer concentration from Operable Unit 1. The predicted concentration for arsenic at 5.855E-06 mg/L is three orders of magnitude less than the maximum detection limit (5.000E-03 mg/L), which indicates that arsenic concentrations, if present near or at the maximum detection limit, could be due to sources other than Operable Unit 1.

D.2.6.2 SWIFT Loading from Paddys Run

Based on the characteristics of the infiltration from Paddys Run to the Great Miami Aquifer, a conceptual model was developed for the surface water to groundwater pathway for the Operable Unit 1 waste areas (Figure D.2-1). Surface water carrying dissolved contaminants in Paddys Run as described in Section D.2.2 can infiltrate into the Great Miami Aquifer in locations where the streambed lies in direct contact with the aquifer. Based on previous Paddys Run flow and infiltration studies (DOE 1993b), 30 percent of the runoff effluent volume is assumed to infiltrate to the Great Miami Aquifer

through Paddys Run during storm events. The linear extent of the 83 grid cells along Paddys Run which were used for contaminant loading to the Great Miami Aquifer is shown on Figure D.2-3. For modeling purposes, mass loading from Paddys Run to the Great Miami Aquifer included those grid cells which were located between the uppermost reach of Paddys Run adjacent to Operable Unit 1 and the FEMP property boundary where Paddys Run exits the site.

Using the results of the surface water modeling and constituent screening process described in Subsection D.2.6.1, the loading rates of each compound were used to calculate the expected loading which would occur in the Great Miami Aquifer. The calibrated groundwater flow model for the FEMP was then used to simulate the solute transport of the compounds in the Great Miami Aquifer as further described in Section D.3.7.

REFERENCES

4787

- Atlantic Environmental Services (AES), 1988, "Management of Manufactured Gas Plant Sites," Vol. III, Risk Assessment, Gas Research Institute, Chicago, IL, GRI-87/0260.3.
- Dames and Moore, 1985. Groundwater Task C Report, Department of Energy Feed Materials Production Center, prepared for National Lead of Ohio, Inc., Cincinnati, OH.
- Haith, D. A., 1980, "A Mathematical Model for Estimating Pesticide Losses in Runoff," Journal of Environmental Quality, Vol 9, No.3, pp. 428-433.
- Hershfield, D. M., 1961, "Rainfall Frequency Atlas of the United States: For Durations from 30 Minutes to 24 Hours and Return Periods From 1 to 100 Years," U.S. Department of Commerce, Washington, D.C., Technical Paper No. 40.
- Mills, W. B., J. D. Dean, D. B. Porcella, S. A. Gherini, R. J. M. Hudson, W. E. Frick, G. L. Rupp, and G. L. Bowie, 1982, "Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants: Parts 1, 2, and 3," EPA-600/6-82-004 a,b,c, U.S. Environmental Protection Agency, Environmental Research Laboratory, Office of Research and Development, Athens, GA.
- Mills, W. B., D. B. Porcella, M. J. Unga, S. A. Ghevini, K. V. Summers, Lingfung Mok, G. L. Rupp, G. L. Bowie, and D. A. Haith, 1985, "Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Groundwater," EPA/600/6-85/002a, U.S. Environmental Protection Agency, Environmental Research Laboratory, Office of Research and Development, Athens, GA.
- Mockus, J., 1972, "Estimation of Direct Runoff from Storm Rainfall," In National Engineering Handbook, Section 4, U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C.
- U.S. Department of Energy, 1993a, "Remedial Investigation for Operable Unit 4," Fernald Environmental Management Project, Fernald, OH.
- U.S. Department of Energy, 1993b, "Paddys Run Flow and Infiltration Model Report: Description and Results," prepared for the U.S. Department of Energy Fernald Field Office by IT Corporation.
- U.S. Environmental Protection Agency, 1988, "Superfund Exposure Assessment Manual," EPA/540/1-88/001, Office of Remedial Response, U.S. EPA, Washington, D.C.
- U.S. Environmental Protection Agency, 1993, "Risk-Based Concentration Table, Second Quarter for 1993," U.S. Environmental Protection Agency, Region III Memorandum dated May 10, 1993, Philadelphia, PA.

0095

TABLE D.2-1

4787

AVAILABLE POTENTIAL CONSTITUENT OF CONCERN CONCENTRATIONS IN
SURFACE SOILS AT OPERABLE UNIT 1^a

Constituent	Upper 95% CI Concentration
Inorganics^b	
Antimony	27.2
Arsenic	4.9
Barium	56.9
Beryllium	0.8
Cadmium	5.8
Chromium	14.3
Cobalt	10.4
Copper	17.0
Cyanide	0.3
Lead	15.9
Manganese	574.1
Mercury	0.1
Molybdenum	4.3
Nickel	29.4
Selenium	0.6
Silver	8.9
Thallium	0.7
Vanadium	19.6
Zinc	46.7
Organics^c	
4,4'-DDT	ND ^d
Aroclor-1221	ND
Aroclor-1248	ND
Aroclor-1254	1400.0
Aroclor-1260	200.0
Radionuclides^e	
Cesium-137	1.0

0096

4787

TABLE D.2-1
(Continued)

Constituent	Upper 95% CI Concentration
Neptunium-237	0.5
Plutonium-238	0.4
Plutonium-239-240	0.1
Ruthenium-106	ND
Strontium-90	1.7
Technitium-99	8.7
Thorium-230	74.9
Thorium-232	4.3
Uranium-234	60.1
Uranium-235	6.8
Uranium-238	244.7
Uranium-Total	731.23 ^f (mg/kg)

^a Surface soil concentrations from the CIS surface soil data set.

^b All concentrations in milligrams per kilogram (ppm).

^c All concentrations in micrograms per kilogram (ppb).

^d ND indicates constituent was not detected in any samples in the CIS surface soil data set.

^e All concentrations in picocuries per gram (pCi/g) except Uranium-total which is in micrograms per gram (ppm).

^f Uranium-Total concentration derived from Uranium-238 concentration from CIS surface soil data (244.7 pCi/g 0.337 [a conversion factor to micrograms per gram] 0.997 [ratio of U-238 to U-234 + U-235 + U-238]). All other radionuclide concentrations are in pCi/g.

0097

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TABLE D.2-2

VARIABLES USED IN THE SURFACE WATER RUNOFF MODEL

Variables	Units	Values
C, cover factor ^a	unitless	0.042
LS, product of slope length factor and slope steepness factor ^b	unitless	0.25
K, soil erodibility factor ^a	metric tons/ha/unit erosion potential	0.37
θ_c , available water capacity ^c	unitless	0.15
q_p , peak runoff flow rate ^d	m ³ /s	0.04
Q_r , depth of runoff ^e	cm	1.25
R_r , depth of rainfall during event ^e	cm	6.35
A, contaminated area ^c	hectares	17.2
T_r , storm duration ^f	hr	24
V_r , volume of runoff ^c	m ³	2146
P, erosion control practice factor ^b	unitless	1.0
CN, SCS runoff curve number ^g	unitless	71

^aAtlantic Environmental Services (AES), 1988, Exhibit 7-5.^bU.S. Environmental Protection Agency, 1988, Figure 2-6.^cCalculated from site-specific information.^dCalculated in Section D.2.3.2.^eAES, 1988, Exhibit 7-11; Mills et al., 1985.^f1-year, 24-hour storm event (Hershfield, 1961).^gMills et al., 1985.

0098

TABLE D.2-3

MODELED CONCENTRATIONS IN PADDYS RUN AND
THE GREAT MIAMI RIVER

MUSLE Constituents	Paddys Run Sediment Concentration (mg/kg)	Paddys Run Loading (lb/day)	Paddys Run Concentration Cw (mg/l)	Great Miami River Concentration Cgmr (mg/l)
Inorganics				
Antimony	2.720×10^1	4.000×10^{-7}	5.540×10^{-4}	5.540×10^{-7}
Arsenic	4.900×10^0	9.010×10^{-8}	1.040×10^{-4}	1.250×10^{-7}
Barium	5.69×10^0	1.840×10^{-7}	2.110×10^{-4}	2.541×10^{-7}
Beryllium	8.000×10^{-1}	2.260×10^{-9}	2.600×10^{-6}	3.133×10^{-9}
Cadmium	5.800×10^0	4.270×10^{-8}	4.900×10^{-5}	5.905×10^{-8}
Chromium	1.430×10^1	3.510×10^{-8}	4.030×10^{-5}	4.854×10^{-8}
Cobalt	1.040×10^1	6.950×10^{-8}	8.000×10^{-5}	9.626×10^{-8}
Copper	1.700×10^1	5.000×10^{-7}	5.750×10^{-4}	6.919×10^{-7}
Cyanide	8.92×10^{-2}	7.65×10^{-6}	8.80×10^{-3}	1.059×10^{-5}
Lead	1.590×10^1	1.950×10^{-8}	2.240×10^{-5}	2.699×10^{-8}
Manganese	5.74×10	1.17×10^{-5}	1.350×10^{-2}	1.623×10^{-5}
Mercury	9.90×10^{-2}	3.64×10^{-8}	4.19×10^{-5}	5.041×10^{-8}
Molybdenum	4.300×10^0	1.760×10^{-7}	2.020×10^{-4}	2.430×10^{-7}
Nickel	2.940×10^1	1.660×10^{-7}	1.910×10^{-4}	2.303×10^{-7}
Selenium	6.00×10^{-1}	2.98×10^{-9}	3.43×10^{-6}	4.128×10^{-9}
Silver	8.890×10^0	1.820×10^{-7}	2.090×10^{-4}	2.516×10^{-7}
Thallium	7.000×10^{-1}	1.72×10^{-9}	1.97×10^{-6}	2.376×10^{-9}
Vanadium	1.960×10^1	7.210×10^{-8}	8.290×10^{-5}	9.979×10^{-8}
Zinc	4.670×10^1	7.160×10^{-8}	8.230×10^{-5}	9.907×10^{-8}
Organics				
Aroclor-1254	1.400×10^0	7.690×10^{-11}	8.840×10^{-8}	1.064×10^{-10}
Aroclor-1260	2.000×10^{-1}	1.19×10^{-10}	1.37×10^{-7}	1.648×10^{-10}
Radionuclides				
Cesium-137	1.150×10^{-8}	2.330×10^{-17}	2.680×10^{-14}	3.232×10^{-17}
Neptunium-237	7.070×10^{-4}	4.730×10^{-11}	5.440×10^{-8}	6.544×10^{-11}

TABLE D.2-3
(Continued)

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MUSLE Constituents	Paddys Run Sediment Concentration (mg/kg)	Paddys Run Loading (lb/day)	Paddys Run Concentration Cw (mg/l)	Great Miami River Concentration Cgmr (mg/l)
Plutonium-238	2.333×10^{-8}	5.050×10^{-17}	5.810×10^{-14}	6.990×10^{-17}
Plutonium-239 and 240	1.610×10^{-6}	3.480×10^{-15}	4.000×10^{-12}	4.819×10^{-15}
Strontium-90	1.230×10^{-8}	4.530×10^{-15}	5.210×10^{-12}	6.276×10^{-15}
Technetium-99	2.760×10^{-4}	8.590×10^{-9}	9.880×10^{-6}	1.190×10^{-8}
Thorium-230	3.710×10^{-3}	2.350×10^{-12}	2.700×10^{-9}	3.256×10^{-12}
Thorium-232	3.930×10^1	2.490×10^{-8}	2.860×10^{-5}	3.448×10^{-8}
Uranium-234	9.540×10^{-3}	2.930×10^{-9}	3.360×10^{-6}	4.050×10^{-9}
Uranium-235	3.120×10^0	9.560×10^{-7}	1.100×10^{-3}	1.323×10^{-6}
Uranium-238	7.240×10^2	2.220×10^{-4}	2.550×10^{-1}	3.072×10^{-4}

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TABLE D.2-4

COMPARISON OF MODELED RESULTS TO MEASURED
SURFACE WATER CONCENTRATIONS IN PADDYS RUN

Constituent of Potential Concern ^a	Modeled Concentration in Paddy's Run ^b	Range of Measured Concentrations in Paddy's Run
Radionuclides (pCi/l)		
Thorium-230	5.45×10^{-2}	<1.0-2.3 ^c
Thorium-232	3.13×10^{-3}	<1.0 ^c
Uranium-234	2.10×10^1	1.2-3.6 ^c
Uranium-238	8.55×10^1	2.0-6.8 ^c
Inorganics (g/l)		
Cadmium	0.049	<2 ^d
Chromium	0.0403	<10 ^d
Copper	0.575	<10 ^d
Lead	0.0224	7.4-9.3 ^d
Nickel	0.191	<20 ^d
Silver	0.0209	<10 ^d

^aCOC listed only if measured data were available for comparison.^bModeled from surface soil source term.^cFrom Operable Unit 4 Remedial Investigation, U.S. Department of Energy, 1993, Table 4-SW, surface water sample locations W-10 and W-11.^dASI/IT, Geochemical Program Issues 3 and 5.

TABLE D.2-5

PADDYS RUN LOADING - SCREENING FOR SWIFT

4782

MUSLE Constituents	Runoff Effluent Concentration C_e (mg/l)	Predicted Diluted Aquifer Concentration C_{GMA} (mg/l)	10^{-7} Risk-Based or 0.1 Hazard Quotient Screening Level (mg/l)	SWIFT Modeling Status
Inorganics				
Antimony	2.570×10^{-3}	2.603×10^{-5}	1.500×10^{-3}	No
Arsenic	5.780×10^{-4}	5.855×10^{-6}	4.60×10^{-6}	Yes
Barium	1.180×10^{-3}	1.195×10^{-5}	2.600×10^{-1}	No
Beryllium	1.450×10^{-5}	1.419×10^{-7}	1.900×10^{-6}	No
Cadmium	2.740×10^{-4}	2.775×10^{-6}	1.800×10^{-3}	No
Chromium	2.250×10^{-4}	2.279×10^{-6}	1.800×10^{-2}	No
Cobalt	4.470×10^{-4}	4.528×10^{-6}	2.0×10^{-1}	No
Copper	3.210×10^{-3}	3.251×10^{-5}	1.400×10^{-1}	No
Cyanide	4.910×10^{-2}	4.973×10^{-4}	1.800×10^{-2}	No
Lead	1.250×10^{-4}	1.266×10^{-6}	1.500×10^{-3}	No
Manganese	7.530×10^{-2}	7.627×10^{-4}	1.800×10^{-2}	No
Mercury	2.340×10^{-4}	2.370×10^{-6}	1.100×10^{-3}	No
Molybdenum	1.130×10^{-3}	1.145×10^{-5}	1.800×10^{-2}	No
Nickel	1.070×10^{-3}	1.084×10^{-5}	7.300×10^{-2}	No
Selenium	1.920×10^{-5}	1.945×10^{-7}	1.800×10^{-2}	No
Silver	1.170×10^{-3}	1.185×10^{-5}	1.800×10^{-2}	No
Thallium	1.100×10^{-5}	1.114×10^{-7}	2.900×10^{-4}	No
Vanadium	4.630×10^{-4}	4.690×10^{-6}	2.600×10^{-2}	No
Zinc	4.600×10^{-4}	4.659×10^{-6}	1.100×10^{-10}	No
Organics				
Aroclor-1254	6.460×10^{-6}	6.543×10^{-8}	1.00×10^{-5}	No
Aroclor-1260	7.640×10^{-7}	7.739×10^{-9}	1.00×10^{-5}	No
Radionuclides				
Cesium-137	1.500×10^{-13}	1.519×10^{-15}	2.200×10^{-12}	No
Neptunium-237	3.040×10^{-11}	3.079×10^{-9}	3.400×10^{-8}	No
Plutonium-238	3.240×10^{-11}	3.282×10^{-15}	1.400×10^{-12}	No

TABLE D.2-5
(Continued)

MUSLE Constituents	Runoff Effluent Concentration C_e (mg/l)	Predicted Diluted Aquifer Concentration C_{GMA} (mg/l)	10^{-7} Risk-Based or 0.1 Hazard Quotient Screening Level (mg/l)	SWIFT Modeling Status
Plutonium-239/240	2.240×10^{-11}	2.269×10^{-13}	3.700×10^{-10}	No
Strontium-90	2.910×10^{-11}	2.948×10^{-13}	1.100×10^{-12}	No
Technetium-99	5.520×10^{-5}	5.591×10^{-7}	2.400×10^{-7}	Yes
Thorium-230	1.510×10^{-8}	1.529×10^{-10}	2.000×10^{-8}	No
Thorium-232	1.600×10^{-4}	1.621×10^{-6}	2.900×10^{-4}	No
Uranium-234	1.880×10^{-5}	1.904×10^{-7}	5.300×10^{-8}	Yes
Uranium-235	6.140×10^{-3}	6.219×10^{-5}	1.500×10^{-4}	No
Uranium-238	1.430×10^{-0}	1.448×10^{-2}	5.600×10^{-4}	Yes

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TABLE D.2-6

4787

COMPARISON OF SELECTED 2000-SERIES WELL CONCENTRATIONS TO
PREDICTED MAXIMUM DILUTED AQUIFER CONCENTRATIONS

Surface Water Pathway COC	Well 2009 ^a (mg/l)	Well 2108 ^a (mg/l)	Well 2004 ^a (mg/l)	Well 2107 ^a (mg/l)	Predicted Diluted Aquifer Concentration (g/l)
Arsenic	5.000×10^{-3b}	NA	5.000×10^{-3b}	$5.000_{3b} \times 10^{-}$	5.855×10^{-6}
Technetium-99	NA ^c	NA	8.247×10^{-7}	NA	5.591×10^{-7}
Uranium-234	4.597×10^{-7}	1.592×10^{-6}	5.494×10^{-7}	2.467×10^{-7}	1.904×10^{-7}
Uranium-238	1.253×10^{-2}	2.959×10^{-2}	1.850×10^{-2}	6.444×10^{-3}	1.448×10^{-2}

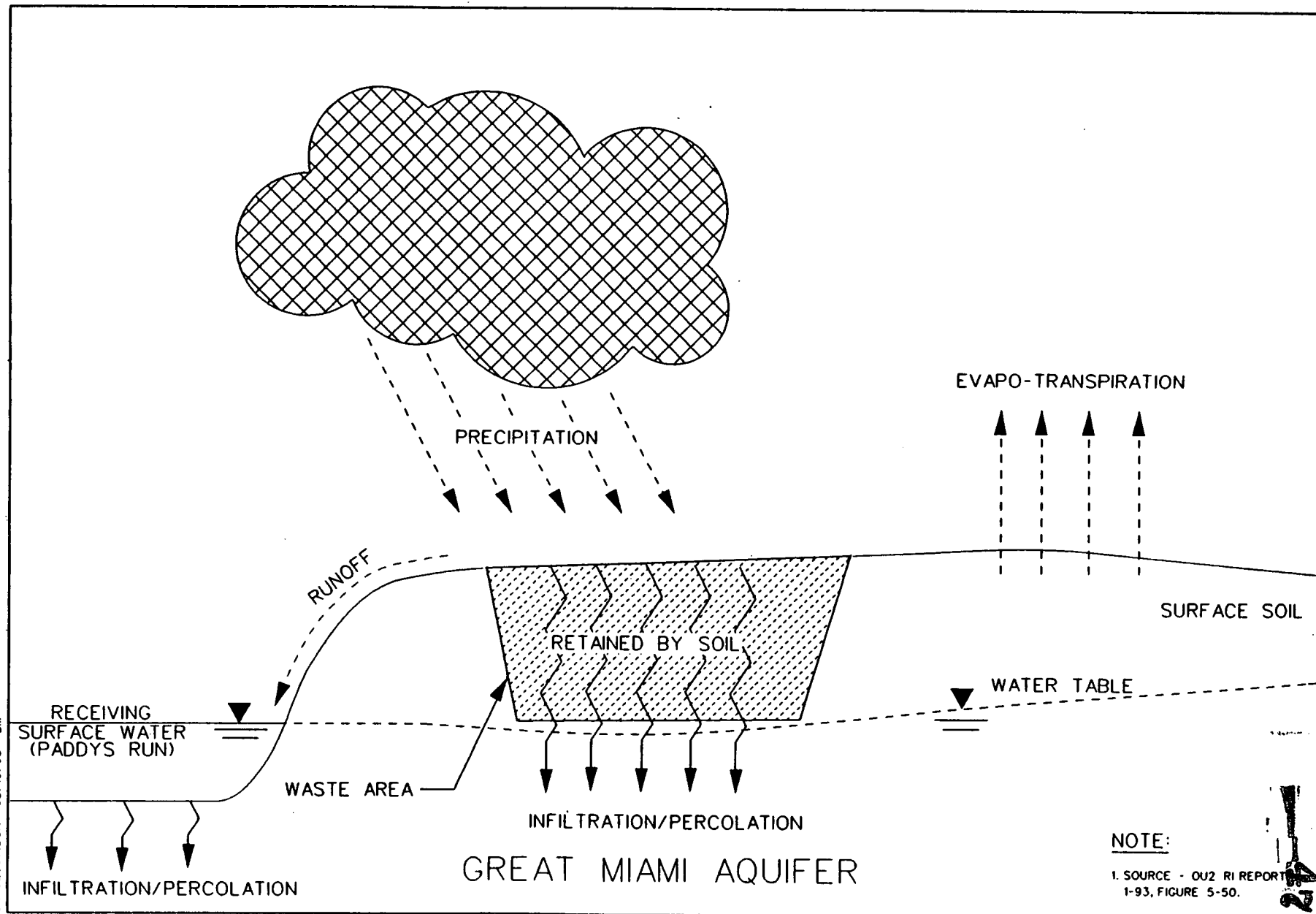
^a Concentration from FEMP groundwater data base. Unless otherwise indicated, the concentration represents the maximum detected concentration over 12 sampling events from 1990 through 1992.

^b Sample concentration was below detection limit so the maximum detection limit was used.

^c NA - data not available.

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SKX02067-A OUT FAR
SKX02067.DGN 08/10/93 BM



NOTE:

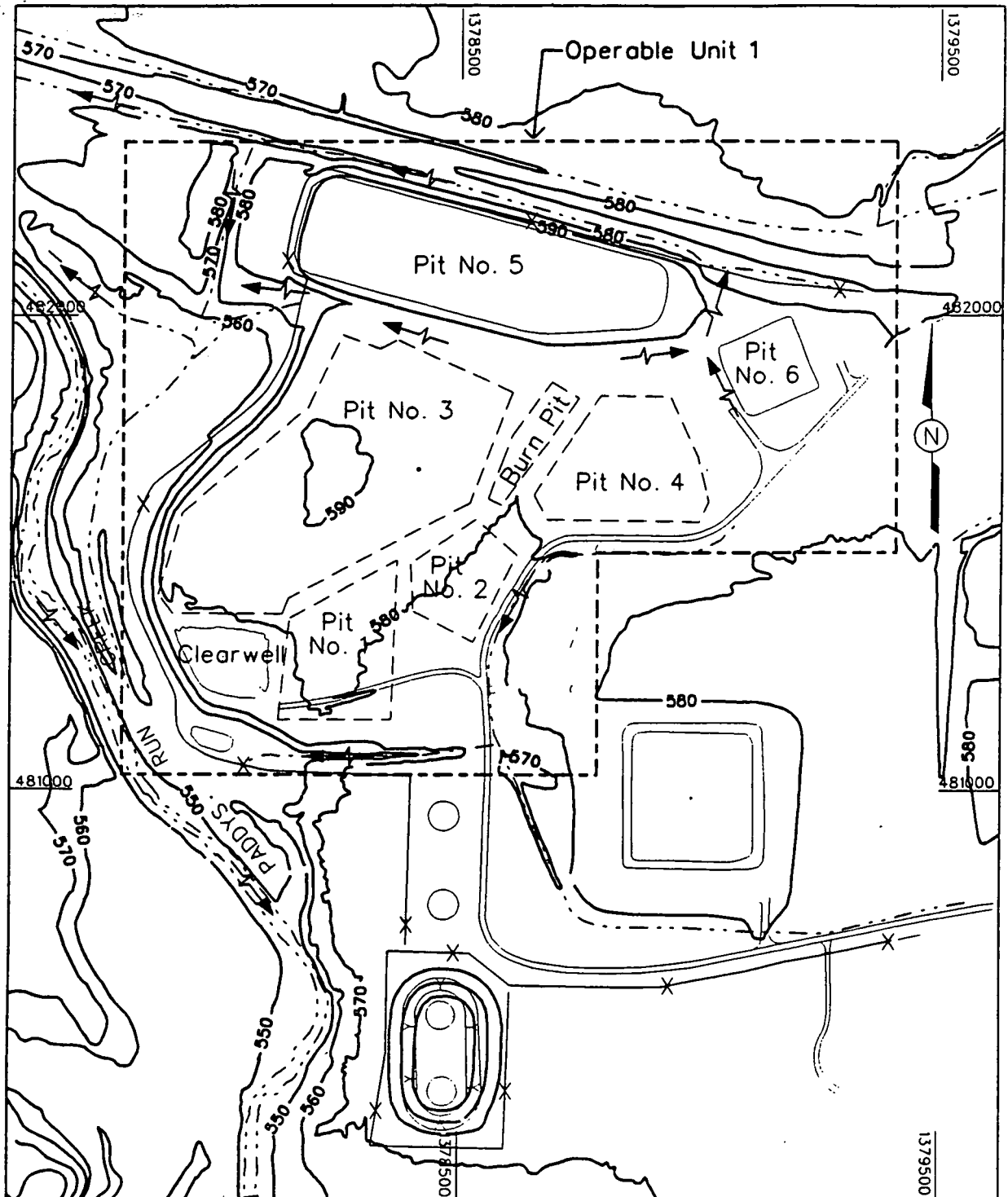
1. SOURCE - OU2 RI REPORT
1-93, FIGURE 5-50.

FIGURE D.2-1. CONCEPTUAL MODEL OF SURFACE WATER RUNOFF

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**NOTE:**

1. CONTOUR INTERVAL - 10 FT.
2. SOURCE - RIQU1 REPORT, 2-93, FIGURE 5-51.
3. DRAINAGE SCENARIO BASED ON DRAINAGE - PRIOR TO INSTALLATION OF STORM WATER RUNOFF CONTROL

LEGEND:

- ✕ — ✕ FENCE LINE
- - - DRAINAGEWAYS
- ==== ROADWAY
- - - - OPERABLE UNIT OUTLINE
- ▶— SURFACE WATER DRAINAGE
- 580 - TOPOGRAPHIC CONTOUR LINE

SCALE:

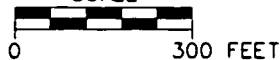


FIGURE D.2-2. TOPOGRAPHY AND NATURAL DRAINAGE SCENARIO OF OPERABLE UNIT 1

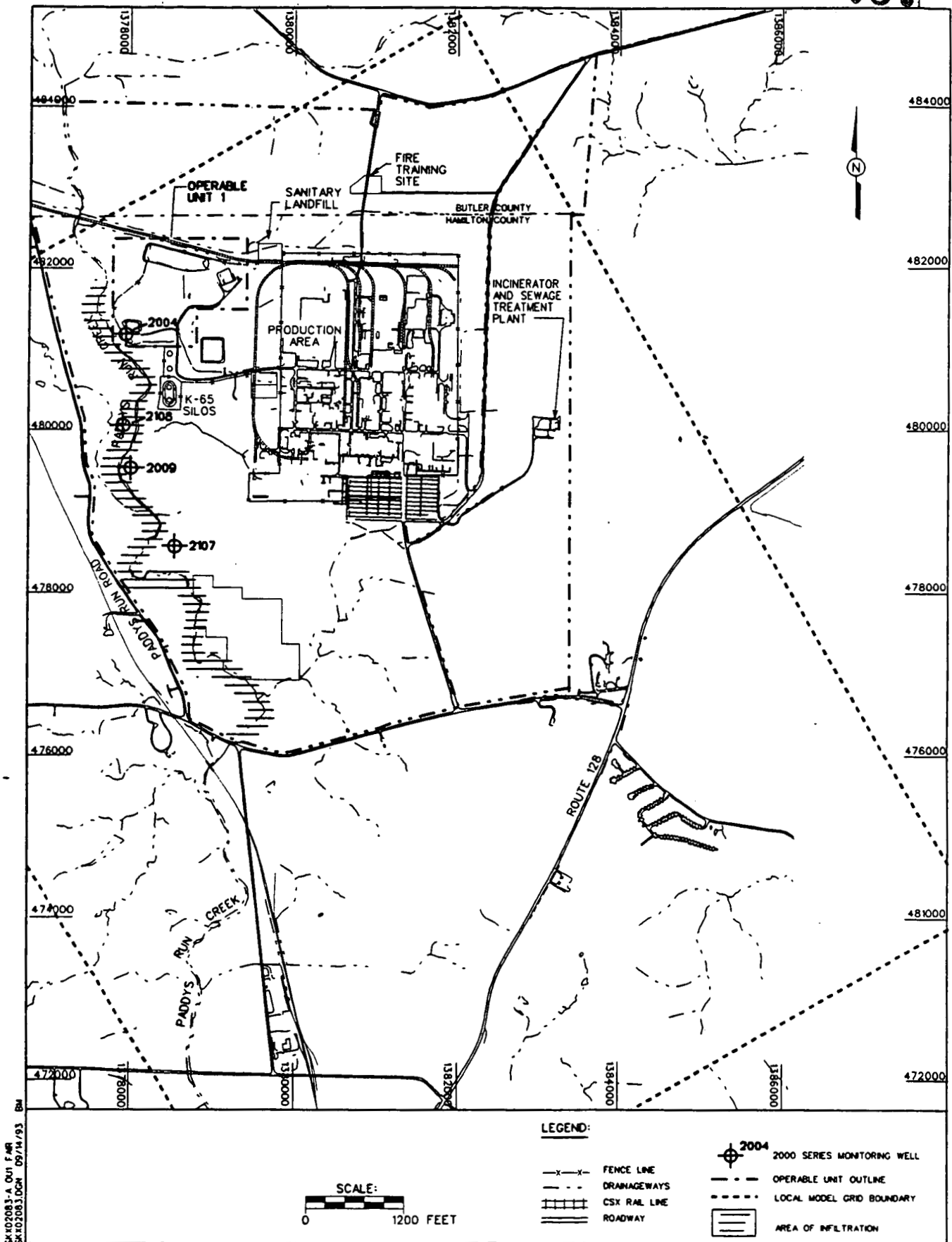
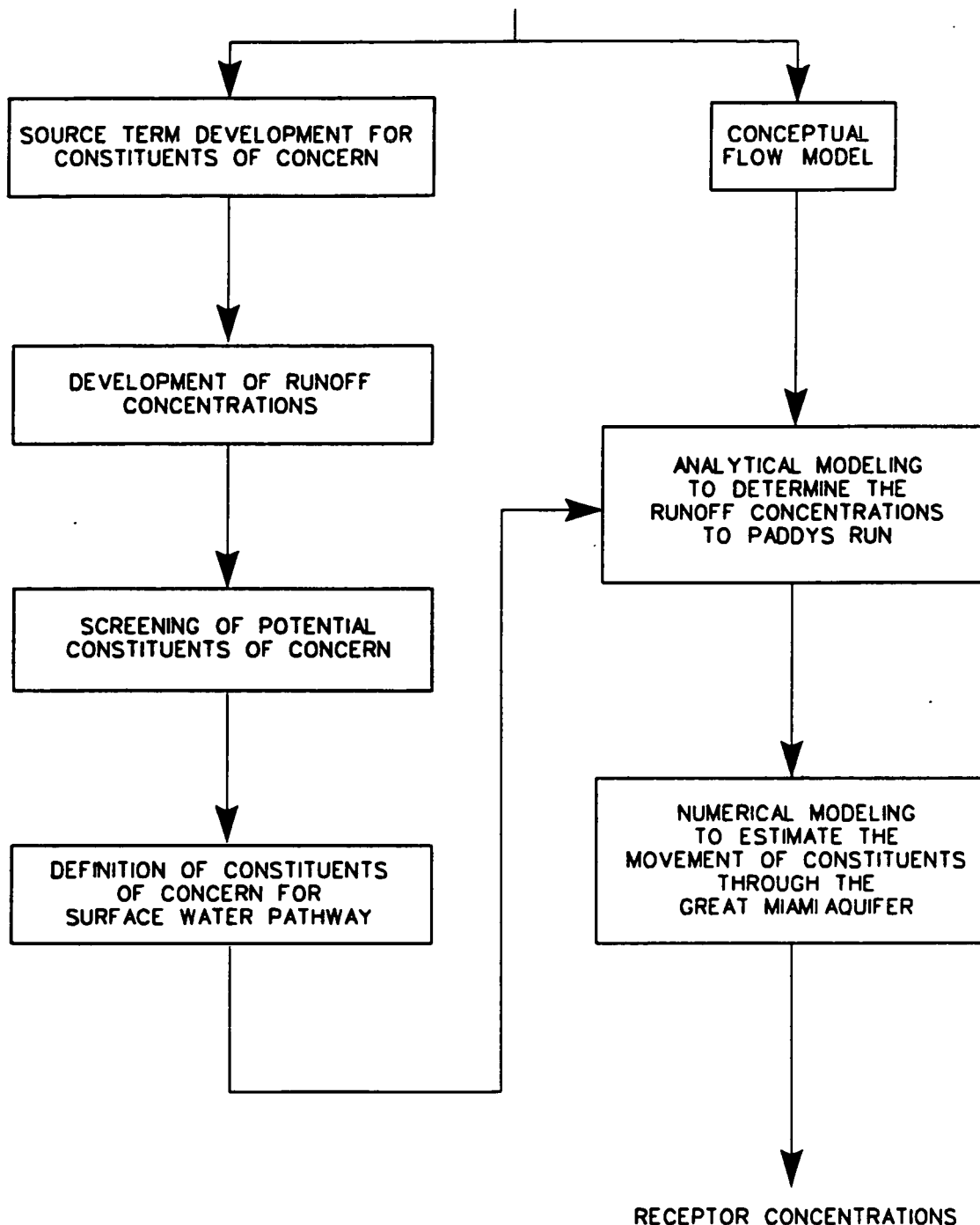


FIGURE D.2-3. LINEAR EXTENT OF PADDY'S RUN INFILTRATION TO THE GREAT MIAMI AQUIFER AND LOCATION OF SELECTED 2000 SERIES WELLS.

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OPERABLE UNIT 1
SURFACE SOILS - SURFACE WATER TO GROUNDWATER PATHWAY



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FIGURE D.2-4. SURFACE WATER TO GROUNDWATER PATHWAY
TRANSPORT MODELING DIAGRAM

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D.3.0 GROUNDWATER FATE AND TRANSPORT MODELING

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D.3.1 INTRODUCTION

The objective of this section is to evaluate the fate and transport of constituents as they migrate from the Operable Unit 1 area through the vadose zone or Paddys Run streambed to the Great Miami Aquifer. This section provides a more detailed discussion of the modeling that is summarized in the main RI Report text (Section 5) and provides the necessary support information for Section 5. The Operable Unit 1 waste areas are Waste Pits 1 through 6, the Burn Pit, and the Clearwell.

Groundwater fate and transport models are used to predict contaminant movement from source volumes (waste areas) to receptor locations through the groundwater pathway. Used in conjunction with monitoring data, these models predict future contaminant concentrations at potential exposure locations where measured contaminant concentration data are not available. The modeling provides the best data on contaminant migration into off-property locations or for future exposure predictions by extrapolating from known field data. Conservative assumptions are used in the modeling to provide a reasonable "worst case" picture of risk. The modeled future concentrations are also based on the unremediated baseline case for the Operable Unit 1 waste areas. The results of the groundwater fate and transport modeling are used in the Operable Unit 1 Baseline Risk Assessment (Appendix E) to estimate potential risks to the environment and human health.

This section presents a description of the technical approach and the methods used to quantitatively predict contaminant concentrations for use in the Operable Unit 1 Baseline Risk Assessments.

This section:

- Presents background information on the hydrogeologic setting
- Defines the conceptual groundwater flow model based upon a reasonable and conservative depiction of the hydrogeologic setting
- Outlines the screening processes to finalize the list of constituents of potential concern (CPC)
- Presents a description and results of vadose zone modeling
- Presents a description and results of aquifer modeling
- Compares modeling results with field data

D.3.1.1 Technical Approach

Two pathways are considered in this analysis. First, migration from the waste unit vertically through the vadose zone to the aquifer is designated the vadose zone pathway. Second, migration of contaminants from the surface soil to Paddys Run and from Paddys Run to the aquifer is designated

the surface water pathway. This section considers all of the steps of the vadose zone pathway. For the surface water pathway, Section D.2.0 describes the definition of constituents, the conceptual model for the surface water pathway, the surface water modeling, the screening of constituents, and the predicted concentrations in Paddys Run and the Great Miami River. This current section, however, presents all of the Great Miami Aquifer modeling results including the concentrations in the aquifer due to mass loadings from Paddys Run.

Figure D.3-1 shows, for the vadose zone pathway, the steps in model development and the method of deriving the source and leachate concentrations. The extent to which contaminants may migrate through the groundwater system depends both on site characteristics and the nature of the contaminants. Because of the variety of the contents in the waste areas and the heterogeneity in the vadose zone beneath the waste areas, a separate conceptual model is developed for each of the waste areas in Operable Unit 1. The development of these models involves the following steps:

- Review of the available information on the specific waste area to establish the characteristics of the waste area.
- Identification of CPC by reviewing the production history and by analyzing site characterization data.
- Identification of the hydrologic processes governing the fate and transport of the constituents within each hydrostratigraphic unit.
- Development of a conceptual hydrogeologic model for each waste area, based on information about the contaminants present in that waste area and its location-specific geologic setting.

Once the conceptual models are developed, existing computer codes that allow the creation of a proper mathematical representation of the conceptual models are selected. The mathematical representations used at the FEMP generally consider the rate at which the modeled processes occur, the interaction of different processes with each other, and the initial conditions of both the waste area and the surrounding geologic formations. Some of the major steps involved in constructing mathematical representations of the conceptual models used at the FEMP include:

- Quantification of the concentrations of constituents in the waste area and the physical parameters defining the volume and mass of each waste area.
- Use of measured data and geochemical modeling to determine the chemical speciation projected to result from the reactions of infiltrating water with the waste materials and the matrix of the glacial overburden. (Section D.1.0)
- Definition of physical parameters of the vadose zone system beneath each waste area.

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- Estimation of the rate constants describing the cationic retardation of the modeled contaminants. These rate constants are based on partitioning coefficients selected during an extensive literature search. 1
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- Estimation of the rate constants describing contaminant retardation attributable to interactions with organic carbon in the geological formation. These constants are based upon the grain-size distributions and organic carbon content of the glacial overburden matrix. 4
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- Estimation of the rate constants describing the decay rates of the modeled contaminants. These first-order rate constants are based upon radioactive half-lives and biodegradation half-lives in groundwater for radionuclides and organic chemicals, respectively. 8
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- Calibration of the model to field data. Selected 2000 series wells in the vicinity of the waste pits are evaluated to determine constituents that have reached the aquifer. Initial model results are compared to these data and a constant loading term is added to approximately reproduce these constituent values within the operating time frame. 11
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The CPC from Operable Unit 1 waste areas are defined based upon sampling data and prescreening and background/nutrient screening activities (see Appendix E). Prior to fate and transport modeling, additional screening steps are undertaken to reject those that clearly would not pose a significant risk. By screening constituents, computational time is reduced. Screening steps consider travel time through the vadose zone, organic and radiologic decay, and comparison with toxicity levels. 15
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After existing computer codes and site-specific input parameters are selected, the codes are used to (1) calculate constituent loading rates to the aquifer beneath the selected waste area; and (2) perform flow and solute transport modeling to determine the effects of dispersion, retardation, and contaminant degradation or decay on the projected contaminant concentrations in the Great Miami Aquifer. Estimates of future concentrations in the aquifer are the desired result of the modeling effort. 20
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D.3.1.2 Approach to Screening and Modeling 25

The primary purpose of the fate and transport modeling is to provide predicted concentrations of key, risk-causing constituents so that overall risk may be determined by the risk assessors. Because the modeling is resource intensive, screening steps are undertaken to eliminate constituents that pose little or no risk using conservative assumptions. In addition, because modeling contains uncertainty by being a predictive tool based upon many assumptions, actual monitoring data is reviewed to check certain model results. For example, if a constituent is predicted to be attenuated in the vadose zone for many years, yet it is presently found in the aquifer, then the model assumptions need to be reviewed. 26
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Figure D.3-2 shows the approach that has been followed in screening out constituents, in defining risk from the nonscreened constituents, and in incorporating monitoring results in the modeling process. This figure represents the three screening steps that remove CPCs from further consideration (see detailed discussion in Section D.3.4). In addition, this figure also shows the relationship of the monitoring data evaluation to this process. Figure D.3-3 depicts the five cases for modeling represented schematically on Figure D.3-2.

If a constituent is detected above the detection limits (i.e., Cases 2 and 3) in the Great Miami Aquifer groundwater in the vicinity of the waste areas, then further steps are undertaken. First, these detected concentrations are compared against background and a 10^{-7} risk based criteria for carcinogens or 0.1 Hazard Quotient criteria for non-carcinogens. If these concentrations are below these criteria, then the constituent is screened out since it either is caused by other factors than Operable Unit 1 or it does not pose any risk. Next, if a constituent is detected at concentrations that are higher than background and the screening criteria, then it is calculated whether it will reach the fence line within 1,000 years. If the calculation shows that it will not reach the fence line, then the current maximum concentration is reported at the source location and no impact is assumed at the fence line. If the calculation shows that it will reach the fence line, then the constituent is modeled with the aquifer model (SWIFT).

If constituents are detected in the Great Miami Aquifer sooner than their theoretical arrival time (as determined by the conceptual model parameters and chemical specific factors), then a direct leak loading term to the aquifer is created to represent the present concentration in the aquifer (Figure D.3-3). In theory this term may represent leakage under conditions different than the present waste area configuration or leakage through leaky well casings. In effect, five possible scenarios are created (see Figure D.3-3) that depict different combinations of direct leak source term and vadose zone breakthrough.

D.3.2 HYDROGEOLOGIC SETTING

The first step in developing the pathway analysis is to develop a conceptual understanding of the depositional history of the site and the general hydrogeologic characteristics of the deposits. This section describes the general geology and hydrogeology of the FEMP. For a detailed discussion, refer to the Groundwater Report (DOE 1990).

D.3.2.1 Geologic Setting

The geology of the area is dominated by the glacial and glaciofluvial deposits formed during the most recent continental glaciation (approximately 70,000 years before present). Prior to the advancement of the glaciers, a large valley was eroded into the shale bedrock. This valley, which is approximately 200 feet below the existing land surface, was filled with well-sorted sand and gravel glacial outwash during the retreat of early glaciers. Beneath the site, this outwash is divided by a clay layer at a depth of 120 feet below the current surface. Later glacial advances (Shelbyville) caused the displacement of

the Dry Fork of the Whitewater River from its historic channel into its present channel. The Shelbyville ice deposited a moraine in the historic channel which formed a dam. The meltwater lake that formed behind the dam gave rise to the lacustrine deposits found in the area. This dam was breached at least two times, with the final breach draining the lake permanently. The lake basin is now occupied by Paddys Run.

In the Paddys Run floodway, recent deposits of silt (loess, fluvial, and lacustrine) form a terrace above the current stream elevation. Paddys Run has cut through this recent terrace and the glacial drift. The bed of Paddys Run is located on the well-sorted outwash material which fills the buried valley, on preglacial Whitewater River deposits. Since the last retreat of the continental glaciers, the streams in the area have removed much of the till and lacustrine mantle left by the ice sheets. In the Great Miami River valley, the stream has eroded through the till and is now in direct contact with the glaciofluvial outwash deposits that contain the buried valley aquifer.

The term glacial overburden has been selected to describe the deposits located stratigraphically above the glaciofluvial material of the Great Miami Aquifer. The glacial overburden includes the following types of materials:

- Loess - Considered ubiquitous in the Fernald area, it generally forms the uppermost layer of the glacial overburden. Loess is generally a homogeneous fine-grained blanket deposit, buff to light yellow or yellowish-brown in color. The deposit originated from windblown dust of Pleistocene age carried from the unconsolidated glacial and glaciofluvial deposits uncovered by glacial recession, but prior to the invasion of a vegetative cover.
- Lacustrine - Lacustrine deposits from the glacial lake consisting of well-sorted, stratified fine sands and clays formed in the Paddys Run valley. These varved clays can be interbedded with well-sorted beach deposits along the margins of the former lake basin.
- Till - Undifferentiated glacial till makes up the majority of the glacial overburden at the FEMP site. Because of its location at the ice margin, the till is likely to have been deposited by several modes including moraine deposits, ablation till, and subglacial till sheets arising from differing ice lobes. The primary feature of tills is that they are deposited directly by a glacier without fluvial sorting. The till at the site is a heterogeneous mixture of clays, silts, and pebbles.
- Glaciofluvial - Interbedded with the till are glaciofluvial beds that originated from meltwater streams that occurred along the margins of the ice sheets. These deposits of varying extent consist of well-sorted sands and fine gravels.

D.3.2.2 Vadose Zone

The unsaturated or vadose zone exists above the groundwater table or phreatic surface of the aquifer. In this zone, the interstices are occupied partially by water and partially by air. The partially filled soil water in the unsaturated zone is known as vadose water. Overlying the Great Miami Aquifer at the FEMP are approximately 15 to 35 feet (4.6 to 11 m) of unsaturated sand and gravel outwash deposits. These deposits are assumed to have the same hydraulic characteristics as the underlying saturated material since their depositional histories are the same.

Dense, fine-grained glacial overburden overlie the unsaturated sand and gravel outwash deposits. These types of deposits have intergranular hydraulic conductivities that are very low, with values in the range of 10^{-7} to 10^{-5} feet/day (10^{-11} to 10^{-9} cm/s) (Heath 1983). Extensive deposits of clayey till can cause isolation from zones of near-surface groundwater flow.

In the Great Plains region and in parts of the Midwest, deposits of clayey or silty clay and glaciolacustrine clay have networks of predominantly vertical joints or fractures. This jointing pattern in the Wisconsin tills has also been noted in the area surrounding the FEMP (Brockman 1988). In the FEMP area, the joints which are commonly near vertical have a polygonal expression and are typically 18 to 25 inches (0.46 to 0.63 m) across. The joints are generally oxidized approximately 2 inches on either side of the joint. Within the FEMP, fractures have been noted in the till during the RI/FS drilling program and field reconnaissance. These fractures can impart an enhanced bulk hydraulic conductivity of up to 1000 times greater than that of an unweathered till (Hendry 1988). As a result of increased lateral stresses caused by overburden loading, the hydraulic conductivity of fractured till and clay decreases with depth.

Recent investigations in similar geologic settings indicate that till deposits can be divided from a hydrogeologic standpoint into a brown weathered zone and a gray unweathered zone (Barari and Hedges 1985; Hendry 1988; Cravens and Ruedisili 1987). These studies indicate that infiltration is primarily limited to the weathered till. While precipitation enters this upper zone, it does not act as a significant source of recharge to deeper aquifer zones and the majority of the water lost from till deposits is from evapotranspiration. In addition to the losses due to evapotranspiration, some water may be discharged to small seeps or drainages.

Although the degree of fracturing within the brown tills at the FEMP has not been documented, sufficient observations have been made at the site and in the literature to indicate their presence is a characteristic physical property of these tills. Since fractures have been noted as a dominant feature in most brown tills, it is necessary to consider the effect that these fractures have on water and contaminant transport within the tills. As stated earlier, fractures have been reported to enhance the bulk hydraulic conductivity of till as much as 1000 times with an expected increase of one to three times. It is reasonable to expect that contaminants will be transported by seepage more quickly through

fractured till than unfractured till. At the FEMP, the gray till, with its appreciable silt and clay content, was regarded as providing the Great Miami Aquifer with protection from activities at the site (Dove and Norris 1951). This line of reasoning has justification because the low hydraulic conductivity produces very low velocities even if the hydraulic gradients are large. In addition, most contaminants being transported by seepage through the till matrix undergo attenuation and retardation.

If the till is fractured, these generalizations are not applicable because the velocities of water in the fractures are relatively large compared to the intergranular pore velocities in the unfractured matrix. It should be kept in mind that although the velocities are relatively large, the contaminant flux may be relatively small because the flow rate through the fractures is small.

Fractures not only control velocity but they generally impart a lower capability for attenuation and retardation by adsorption of contaminants. The adsorption processes are capable of removing more contaminant mass from solution if the water is in contact with larger surface areas in the matrix. Contaminants transported by seepage through till fractures only have an opportunity to react with the mineral constituents present in a veneer layer on the exterior of the fracture. Therefore, when flow occurs in the fractures, there is less surface area available for geochemical reactions that reduce the concentration of a contaminant or slow the movement of that contaminant. The exact nature of attenuation in fractured till is highly site specific and not well quantified. For example, if till fractures are coated with iron oxides, they may impart significant retardation on ionic solutions (Grisak et al. 1976).

Within the till deposits, there are numerous water-bearing zones that have limited interconnection. The majority of these zones are of glaciofluvial origin and consist of small beds of highly-sorted sands and gavel. These beds are probably the result of small meltwater streams that occurred along the ice margin and within the glacier itself. These intertill perched zone have the following general characteristics:

- High variability in areal extent, thickness, and volume
- Based upon hydrograph analysis, the interconnection between the intertill significantly saturated zones is limited
- Hydraulic conductivities are highly variable with an expected range of 2.8×10^{-5} to 280 feet/day (10^{-8} to 0.1 cm/s) (Freeze and Cherry 1979)
- Porosities range from 22.1 to 36.7, with a mean of 31 percent (Morris and Johnson 1967)

Generally these glaciofluvial interbeds are considered to be water-bearing units within the glacial overburden. However, movement of water and contaminants within these units will be limited due to limited areal and vertical extent and lack of interconnection of these units. The perched groundwater

zones (saturated lenses of higher permeability sands) present beneath Operable Unit 1 waste areas are not modeled separately, but the thickness and the hydraulic properties of the sand lenses are included in the vadose zone modeling. At the FEMP, a series of slug tests on these perched groundwater zones found hydraulic conductivities ranging from 0.0071 feet/day (2.5×10^{-5} cm/s) (Well 1025) to 8.8 feet/day (3.1×10^{-3} cm/s) (Well 1196).

D.3.2.3 Great Miami Aquifer

The hydrogeology of the FEMP and the surrounding area is a textbook example of a glaciofluvial buried valley aquifer (Walton 1970; Fetter 1989; Freeze and Cherry 1979). The primary aquifer in the region is the Great Miami Aquifer, a well-sorted sand and gravel water table system consisting of sand and gravel glacial outwash deposits. Groundwater in the aquifer enters the FEMP area via buried channels on the west, north, and east. Under natural conditions, the primary flow would be across the site to the south. However, large pumping wells east of the FEMP in the Big Bend area of the Great Miami River have created a pronounced cone of depression causing flow at the FEMP to have easterly, southeasterly, and southerly components.

The aquifer is divided by a clay aquitard 1 to 20 feet (0.3 to 6 m) thick at a depth of approximately 120 feet (37 m). Flow direction and magnitude of the Great Miami Aquifer were simulated using SWIFT III, a numerical groundwater flow and solute transport model. Subsequent text describes the modeling effort in more detail.

D.3.2.4 General Contaminant Hydrogeology At The FEMP

The depositional characteristics and the hydrostratigraphic units present at the FEMP impart general contaminant transport characteristics on solutes migrating from the individual waste areas to receptor locations. These characteristics include:

- Solute migration potential: Solutes have a high migration potential through the upper weathered tills due to the fractured nature of the layer. Solute migration can also occur through the unweathered till, however, at a much slower rate. Once the solute reaches the glacial outwash, the solute migration potential is high, based on the high hydraulic conductivity and low adsorption capacity of the matrix.
- Hydraulic intercommunication: The intercommunication between perched water-bearing zones is limited in the glacial environment. Communication between the upper water-bearing zones within the till and the Great Miami Aquifer is also limited but may occur over an extended period of time.
- Adsorption/attenuation characteristics: The layers found within the glacial overburden generally have sufficient organic carbon content to cause retardation of organic constituents. The clay mineralogy would result in significant cation retardation for inorganic constituents. Given the till matrix, it is also unlikely that all of the available sites for adsorption would be used by solutes. Therefore, it is unlikely that adsorption/attenuation breakthrough would occur. Adsorption/attenuation will occur at

lower rates in the regional aquifer due to the lower organic carbon and clay content in the outwash.

Based on the general hydrogeologic and contaminant transport characteristics, there is a potential pathway from the waste areas through the vadose zone to the regional aquifer. Given the high permeability of the glacial outwash, the pathway would extend from the aquifer-vadose interface to downgradient receptors.

D.3.3 CONCEPTUAL MODEL

The Operable Unit 1 waste areas exhibit considerable diversity in their contents and in the physical and chemical characteristics of the vadose zone beneath them. Because of this diversity, the modeling of the contaminant migration through the vadose zone is considered imperative for the estimation of contaminant loading rates to the regional aquifer model. To model the transport of these contaminants, it is necessary to adapt the generic conceptual model presented in the Risk Assessment Work Plan Addendum (DOE 1992) to a series of specific conceptual models for each distinct waste area. These conceptual models consider the following:

- The contents of the waste area
- The presence of standing water in the waste area
- The presence or absence of a discrete cap
- The presence/absence of perched water in the waste area
- The average concentration of contaminants in perched groundwater
- The identifiable geologic strata beneath the waste area
- The presence/absence of sand lenses in the waste area
- The thickness of each layer in the vadose zone
- The vertical permeability of the layers
- The interstitial fluid velocity through each layer based on saturation
- The dispersion coefficients of each layer
- The partition coefficients for each contaminant in each layer

Figure D.3-4 shows a generalized picture of contaminant migration at the FEMP. Two primary pathways are shown. The first pathway includes migration from the waste unit vertically through the vadose zone to the Great Miami Aquifer. The second pathway consists of loading due to surface runoff from contaminated surface soils from the Operable Unit 1 waste areas to Paddys Run and from Paddys Run to the Great Miami Aquifer (see Section D.2.0). For risk assessment purposes, maximum concentrations are considered in the Great Miami Aquifer at the waste unit boundary and at the fence line or property boundary.

Flow and contaminant transport in the vadose zone is conceptualized from the hydrogeology of the site. As discussed previously, the geology of the FEMP site is dominated by glacial sediments. Well-sorted sand and gravel glacial outwash forms the regional Great Miami Aquifer. Beneath the site, this aquifer is divided by a 1- to 20-foot-thick (0.3- to 6-m-thick) clay interbed at an approximate depth of

120 feet (37 m). The receptor pathway considered for this analysis is the upper part of the Great Miami Aquifer above the clay interbed. Contaminant transport in the vadose zone includes the bulk migration of water and dissolved materials from waste (source) areas at the FEMP to the Great Miami Aquifer. This occurs as surface water infiltrates from the surface and percolates through the source of contamination, and its surrounding soil, into the saturated zone. Downward movement of water, driven by the forces resulting from gravitational potential, capillary pressure, and other components of total fluid potential, mobilize the contaminants and carry them through the vadose zone. Vertical transport down through the vadose zone to the aquifer and the horizontal transport through the aquifer to the well of a potential human receptor is illustrated in Figure D.3-4.

Figure D.3-5 presents a generalized conceptual model of the vadose zone pathway. Once through the waste units, water filters through the vadose zone and dissolves materials, forming an aqueous solution (leachate) (see Section D.1.0 for a detailed discussion of the derivation of leachate concentrations). This solution continues to percolate through the soil/waste matrix in the vadose zone as it moves toward the aquifer. The leachate often reacts with the soil/waste matrix through which it flows. These interactions determine what chemical species are present in the percolating water (leachate), and how fast they will move in the unsaturated zone. In this analysis the composition of the leachate and the speed at which individual constituents migrate are treated individually.

The uppermost 20 to 25 feet (6 to 8 m) of the outwash deposits is unsaturated and forms model Layer 2 of the vadose zone conceptual flow model. Overlying the outwash deposits is an unweathered till interbedded with sand and gravel glaciofluvial stringers. Within Layer 1 are sand lenses beneath some portion of Waste Pits 4, 5, 6, and the Burn Pit. The thickness of this till unit (referred to as glacial overburden) which makes up model Layer 1 ranges between 0 and 16 feet (0 and 5 m) for waste areas. A layer of weathered till overlies the gray clay. However, this layer is not included in the vadose zone modeling because of numerous fractures present within this zone. All layer thicknesses were estimated based on geologic boring logs from subsurface investigations conducted across the site.

Based on characteristics of the material underlying each Operable Unit 1 waste area, a detailed conceptual model is developed for the pathways between each waste area and receptor locations. These more detailed models are developed to account for the variable stratigraphies of the soils of the waste areas of Operable Unit 1. These detailed conceptual models are shown on Figures D.3-6 through D.3-12.

These detailed conceptual models show that perched groundwater occurs in the sand lenses within the glacial overburden beneath Waste Pits 4, 5, 6, and the Burn Pit. For the purposes of modeling, the sand lens is assumed to be a uniform 5 feet thick below the entire area of each of these four waste areas. These perched groundwater zones are modeled to represent an additional source of contaminant loading based on the concentration of constituents detected in 1000 series wells located

within Operable Unit 1 from the RI/FS data base. For a particular constituent, an average concentration for each well is calculated over time. The average concentration value is compared to the concentration reported for the last sampling event, and the higher of the two concentration values is averaged for all wells. The resulting single concentration value is used for the modeling. Initial constituent concentrations, concentration terms over time and sorbed mass are defined on these averaged liquid concentrations and the established distribution coefficient (K_d) for each constituent. The volume of groundwater present in the sand lenses is calculated based upon a volume of the sand lens and an average porosity of 39 percent. The migration pathway for contaminated perched groundwater is generally consistent with the overall conceptual model, with the exception that the glacial overburden thickness is halved for the perched groundwater pathway to account for the approximate location of the perched groundwater zones within the glacial overburden.

Based upon uranium, technetium-99 and arsenic results, loading from perched water represents an insignificant contribution (less than 2-3 orders of magnitude) when compared to the contribution from the waste pits. Since other constituents are minor contributors to total risk (see Section D.3.7), perched water concentrations from other CPCs has even less overall impact. Therefore, for the remaining constituents, perched groundwater was not included in the loading to the aquifer.

Table D.3-1 presents the waste area physical parameters including the area, volume of waste material, and dry density. These data were derived from engineering studies (Weston 1986, Parsons 1993, IT 1993). These parameter values are used for calculating masses of constituents and areas for the source terms. The waste areas contained in Operable Unit 1 are assumed to remain in their existing locations for the purposes of the baseline fate and transport modeling. Waste Pits 1, 2, 3, and 4 remain in their covered states and Pits 5 and 6, the Burn Pit, and the Clearwell are assumed to remain in their present states. Waste Pits 1 through 4 are assumed to remain essentially unchanged for the duration of the simulations, with a vegetative cover being established on the surface. Existing membrane liners in all waste areas are considered to be absent for purposes of the fate and transport modeling. Runoff and evapotranspiration are assumed to occur following precipitation events. Waste Pits 5 and 6, the Burn Pit, and the Clearwell are all assumed to remain uncovered and open to incoming precipitation. In addition, precipitation is assumed to pond on the surface of Waste Pits 5, 6 and the Clearwell units and either infiltrate or evaporate. No surface runoff or transpiration is allowed to occur.

D.3.3.1 Parameters

The parameters used to perform the long-term migration analysis can be divided into flow parameters and contaminant transport parameters. Flow parameters affect the velocity of groundwater movement. Contaminant transport parameters affect the rate of migration and the fate of the contaminant. Wherever possible, site-specific values are used for the analyses. Certain parameters, however, are not available for all of the waste areas, and are estimated based on pertinent scientific literature search, geochemical investigations, and are checked for consistency between model results and historical data.

Conservative estimates are used when a range of values are indicated or parameter values are not available. The formulations employed for the estimation of the parameters are described in the Risk Assessment Work Plan Addendum (DOE 1992). Uncertainty in the selection of model parameter values is addressed by performing sensitivity analyses. Sensitivity analyses are performed by varying parameters within reasonable ranges. Additional information regarding the sensitivity analysis is presented in Section D.3.8.

The conceptual model depicting flow in the vadose zone considers two layers. Layer 1 soils consist of unweathered tills, present beneath six of the eight waste units in Operable Unit 1. Beneath the unweathered till is the unsaturated sand and gravel layer (Layer 2) present beneath all the waste units.

The conceptual model and media parameters for Operable Unit 1 waste areas are presented in Tables D.3-2 and D.3-3, respectively. The vertical hydraulic conductivity values for Layer 1 are obtained by dividing the horizontal hydraulic conductivities (representing the average results of slug tests conducted in 1000-series wells in the vicinity of Operable Unit 1) by 10. Sand lenses are also considered in this analysis using a separate hydraulic conductivity value derived from slug test data and calculating the harmonic mean for the overall Layer 1 hydraulic conductivity. The vertical hydraulic conductivity for Layer 2 is obtained by dividing the known horizontal hydraulic conductivity of the sand and gravel aquifer by 10. The factor of 10 represents a typical horizontal to vertical hydraulic conductivity ratio. The vertical hydraulic conductivity is estimated from 0.0114 to 0.0186 feet per day for Layer 1. The vertical hydraulic conductivity of Layer 2 is 45 feet per day for all of the Operable Unit 1 waste areas. As expected, the conductivity of the sand and gravel layer is several orders of magnitude greater than the till layer. Two of the waste units, Waste Pit 3 and the Clearwell, are assumed to rest directly on the unsaturated sand and gravel of the Great Miami Aquifer and thus have no Layer 1 unit.

The vertical flow rates (q) are based on simulations with the Hydrologic Evaluation of Landfill Performance (HELP) model for the dry pits or with a calculation for the wet pits (see discussion below). The estimates of the vertical seepage velocities (V_x) used in the vadose zone transport model are based on the methods presented in the Risk Assessment Work Plan Addendum (DOE 1992). These methods calculate seepage velocity as a function of flow rate (q), porosity, and empirically derived soil factors. The longitudinal dispersion coefficients (D_x), a function of dispersivity, interstitial seepage, velocity and molecular diffusion coefficient are estimated by the methods presented by Biggar and Nielsen (1976), and Mills et al. (1982).

Flow and solute transport through the porous media are not only determined by the parameters considered in the conceptual model description above, they are also affected by retardation factors (R_f) and decay rates. These parameters are both chemical- and media-specific. Tables D.3-4 through D.3-6 show the retardation factors for the vadose zone Layers 1 and 2 for all the CPC for Operable Unit 1 waste areas. These tables also present the radioactive decay constants for radionuclides and the biodegradation coefficients for the organic constituents. These retardation factors and decay rates are used in the screening process, analytical modeling of the vadose zone, and numeric modeling of the aquifer.

The retardation factor is used to account for those reversible reactions that slow the arrival of a contaminant front, but do not act as a sink. The R_f can be expressed as the ratio between the rate of groundwater movement and the rate of contaminant movement. The R_f as a function of the partitioning coefficient of the constituent, the bulk density and moisture content in the vadose zone, was calculated using the formula described by Walton (1984) and Mills et al. (1982). These R_f s have been revised from the Risk Assessment Work Plan Addendum (DOE 1992) based on more conservative assumptions (for transport) of organic content and moisture content (see Table D.3-3). In the vicinity of Operable Unit 1, a distribution coefficient of 12 ml/g for Layer 1 and 1.48 for Layer 2 was based on previous studies and experimental data available (DOE 1993a) which indicates these values are conservatively low. The radioactive decay constants and biodegradation coefficients are estimated based on the degradation rates (Howard et al. 1991) using the formulation presented in the Risk Assessment Work Plan Addendum (DOE 1992).

D.3.4 CONSTITUENT SCREENING AND REVIEW - VADOSE ZONE PATHWAY

The list of CPCs is screened in several ways to eliminate constituents that pose insignificant risk from further analysis. In addition, groundwater monitoring data is reviewed to determine constituents that are found in the aquifer so that these constituents can be evaluated in the computation of total risk. These screening steps are performed because vadose zone and aquifer modeling require long computational times and to allow the analysis to focus on the constituents that cause the high percentage of the risk. Figure D.3-13 shows the different screening steps. These steps include pre-screening and background screening (performed and presented in other sections of the RI), initial source concentration, travel time to the Great Miami Aquifer, and vadose zone output concentration screening (presented in this section), and the review of groundwater monitoring data. Table D.3-7 shows the list of CPCs, the results of different screening steps, and the list of CPCs for fate and transport modeling in the vadose zone pathway.

Each waste pit is treated separately in these screening analyses. The worst case is used to define action, i.e., if any waste pit fails a particular screening, then that constituent is maintained in subsequent analysis. These screening steps are described in sequence in the following sections.

D.3.4.1 Pre-Screening

Pre-screening is performed on the validated sampling and analysis data sets. Each constituent on the data set is evaluated based on the criteria defined in the Risk Assessment Work Plan Addendum (DOE 1992). At this stage in the process, two types of decisions are made:

- Nutrients at or below drinking water standards are screened out
- Constituents that are not detected in waste pit materials are screened out

The results of this pre-screening are presented in Appendix E.2.

D.3.4.2 Background Screening

A second preliminary screening step is conducted to remove constituents that are below background concentrations. Each constituent that passes prescreening is compared to background concentrations following the process defined in Appendix E.2. Constituents with concentrations determined to be below background concentrations are screened out. The results of this background screening are presented in Appendix E.

The constituents that "pass" the prescreening and background screening are designated "potential CPCs" (see Table D.3-7). A total of 71 potential CPCs were defined for Operable Unit 1 fate and transport modeling. These potential CPCs include 13 radionuclides, 21 inorganic constituents, and 37 organic constituents (see Table D.3-7).

D.3.4.3 Travel Time Screening

Constituents are screened based upon travel time to determine those that would not reach the Great Miami Aquifer within the time period of interest (1,000 years) in significant concentrations under conservative conditions. Travel time screening considers both physical time of travel through the vadose zone and radiological and organic decay over this time period.

Travel time screening is performed on potential CPCs based on distance, retardation factor, velocity, and dispersion. Any constituent that fails to reach the Great Miami Aquifer in 1,000 years is screened out. A second screening process involves comparing the organic or radiological decay constants for constituents to the minimum calculated travel time. If a constituent has gone through 30 half lives during this travel time, then it is screened out due to the negligible mass remaining.

Variables that are used in the screening step are:

- Retardation Factor (R_f) in the Vadose Zone
- Soil Seepage Velocity (V)
- Soil Thickness (L) between Waste Pit and Aquifer
- Axial Dispersion Coefficient (D_L)

The mean travel time for a nondecaying CPC (t_m) is the sum of the travel time through Vadose Zone layer 1 and layer 2:

$$t_m = [R_{f1}(L_1/V_1)] + [R_{f2}(L_2/V_2)]$$

where

- t_m = Travel time (day)
- R_{f1} = Constituent retardation factor for vadose zone layer 1 (unitless)
- L_1 = Thickness of vadose zone layer 1 (feet)
- V_1 = Groundwater velocity in vadose zone layer 1 (feet/day)
- R_{f2} = Constituent retardation factor for vadose zone layer 2 (unitless)
- L_2 = Thickness of vadose zone layer 2 (feet)
- V_2 = Groundwater velocity in vadose zone layer 2 (feet/day)

and if $t_m/30$ is less than the half life ($T_{1/2}$) then the constituent is further modeled. In other words, the minimum travel time divided by 30 is less than the half life of the constituent which indicates it reaches the aquifer in significant mass to be considered for further modeling.

A characteristic dispersion parameter is D_L/VL which will be referred to as N_d . Depending on N_d , a fraction, M (Brenner 1962), can be multiplied by t_m to give a time before which exiting concentrations will be negligible. Consequently, if Mt_m is set at 1,000 years, exiting concentrations prior to 1,000 years will be negligible. Thus, a minimum screening retardation factor, $R_{min} = 1000 \times V/ML$ can be defined, above which the mean travel time will be in excess of 1000/ M years and exiting concentrations up to 1,000 years will be negligible. This analysis is conservative in that one-dimensional flow is assumed and the minimum retardation factor that occurs in any vadose layer is used. Table D.3-8 shows the input assumptions for the Operable Unit 1 waste areas.

Table D.3-7 shows the results of the travel time screening. This table breaks the travel time screening into two categories of screening due to advective transport and screening due to radiological or organic decay. The travel time screening removes the majority of the potential CPCs. The advective transport screening step removes 42 of the 71 CPCs. In addition, 8 organic constituents are removed due to decay.

D.3.4.4 Initial Concentration Toxicity Screening

Toxicity screening is performed on the potential CPCs that passed the travel time screening by comparing the initial concentrations for the vadose zone model (Leachate B - see Appendix D.1) with 10^{-7} risk based concentrations for carcinogens or 0.1 Hazard Quotient concentrations for non-carcinogens. These screening concentrations are derived by dividing the 10^{-6} risk based or Hazard

Quotient of 1 concentrations for tap water (US EPA 1993) by 10. Since Leachate B cannot increase in concentration in transport through the vadose zone or aquifer, then Leachate B represents a theoretical maximum concentration in the aquifer. If the initial concentrations for all waste areas is less than the screening concentration, then the constituent is not modeled further. If any waste area includes a value greater than the screening concentration, then the constituent is still modeled for all the waste areas since modeled concentrations from the different waste areas could be additive.

Table D.3-9 presents the results of the initial concentration toxicity screening. Of the constituents that passed the travel time screening, all passed the initial toxicity screening.

D.3.4.5 Vadose Zone Model Toxicity Screening

Prior to performing aquifer modeling, the output from the vadose zone model is again toxicity screened in a manner similar to the initial concentration toxicity screening (see Section D.3.4.4). Since concentrations can only further dilute when leachate mixes with the aquifer waters, this screening step removes constituents that will clearly be below the 10^{-7} risk based or 0.1 Hazard Quotient standard in the aquifer. To perform this screening, the maximum output from the vadose zone model for a particular constituent is compared with the 10^{-7} risk based or 0.1 Hazard Quotient standard. If this maximum value is below the standard, then the constituent is screened out and is not modeled further.

Table D.3-7 shows the results of the second toxicity screening under the column heading of "Screen out ODAST Output." Antimony, barium, cadmium, copper, lead, manganese, mercury, and 4-nitroaniline are screened out because no appreciable concentration of these constituents reached the aquifer within 1,000 years.

D.3.4.6 Review of Monitoring Data

Water samples have been taken from the Great Miami Aquifer and analyzed periodically. The results for the 2000 series wells indicate the degree of contamination from the FEMP operation in the upper Great Miami Aquifer or the first SWIFT layer to date. Four specific wells (2019, 2021, 2027, and 2648) in close proximity to Operable Unit 1 were chosen to represent the degree of existing contamination from Operable Unit 1. Table D.3-10 lists all analysis targets that were found above detection limits in the FERMCO environmental monitoring data base. Many of these targets are not of concern from a toxicity standpoint (e.g., alkalinity, aluminum, potassium, sodium, pH, etc.) and were not included in the list of potential CPCs. It should be noted that organic compounds were not detected in these wells and therefore, are not included in the list of potential CPCs on Table D.3-10. For the remaining potential CPCs that are detected, these constituents are added to the list of CPCs (Table D.3-7).

Table D.3-11 illustrates background screening and calculations of travel-time to reach the nearest property boundary (fenceline) for those potential CPCs which were detected in these wells (refer to Figure D.3-2 for the logic of the overall screening procedure). The maximum concentrations of the potential CPCs found in these wells were compared with background concentrations. For those potential CPCs whose concentrations did not exceed background, no further action is required. For those exceeding background, travel time calculations to reach the fenceline were performed. The travel time calculation were performed using Darcy's Law with an average hydraulic gradient from Operable Unit 1 to the fenceline of 0.000769, an average K_h of 450 ft/day, and an average effective porosity of 0.25. Based on a travel distance of 3,250 feet from the Operable Unit 1 boundary to the east fenceline, a water travel time of 6.43 years was calculated. Thus, the critical retardation factor (R_{crit}) defining whether the fenceline is reached in 1,000 years for a particular potential CPC is 155. If the potential CPC retardation factor is less than 155, then the constituent reaches the fenceline within 1,000 years.

For those CPCs indicated in Table D.3-11 (barium, Sr-90, Tc-99, and the uranium isotopes) which reach the fence line in less than 1000 years, the groundwater model will be calibrated so that early concentrations (0-40 years) will reasonably approximate the concentrations found in the aquifer.

Because there is a significant presence of uranium in the Great Miami Aquifer within 40 years after operations began at Fernald, calibration of the SWIFT model by reduction of the retardation factor would require an unrealistically low sorption ratio based on experimental evidence at FEMP and other sites. Consequently, it is hypothesized that direct leaks to the Great Miami Aquifer occurred, perhaps through deteriorating polyvinyl chloride casings in well-bores or under conditions different than the present system. Consequently, it was decided to use a "direct leak" block as another parameter to assist in the calibration. The leak is deemed to have started at year 10 and persisted for 30 years to year 40. This overall calibration scheme is illustrated in Figure D.3-3. In effect, five possible scenarios are created (see Figure D.3-3) that depict different combinations of the direct leak source term and vadose zone breakthrough. Potential CPCs are categorized into one of these five cases as presented in Table D.3-12.

Case 1 illustrates the case of a potential CPC which has a direct leak to the Great Miami Aquifer and also has a significant loading to the Great Miami Aquifer through the vadose zone (calculated by One-Dimensional Analytical Solute Transport [ODAST]) prior to 1,000 years but separated in time from the direct leak. Case 1 behavior is typical of uranium. Case 2 is similar to Case 1 except that the future releases to the aquifer are insignificant (i.e., concentrations are less than the 10^{-7} cancer risk or 0.1 Hazard Quotient criterion). Case 2 behavior is typical of barium. Case 3 illustrates the case of a CPC which has some current contamination but whose retardation factor is so high that any loading through the vadose zone would not occur until after 1,000 years. Case 3 behavior is typical of thorium-230. Technetium-99 behavior is unusual and is illustrated by Case 4. Technetium-99 is very

4787
mobile and some quantity is expected to have already migrated through the vadose zone. However, to approximate the concentrations found, it is also necessary to have an additive direct leak block. Finally, Case 5 illustrates the case of the many screened out CPCs that are determined by the procedure given in Figure D.3-2 to not pose any risk. SWIFT modeling is required only for CPCs that fall into Case 1 or Case 4, or Cases 2 and 3 when a contaminant already in the Great Miami Aquifer can reach the fenceline.

D.3.4.7 Summary of CPCs

Table D.3-12 presents the summary of the modeling status of the different CPCs. This table shows the constituents that have passed the screening (Table D.3-7) and that have been found in groundwater (Table D.3-10). For constituents that have been found in groundwater, it was determined based upon groundwater travel time and constituents retardation factors whether a particular constituent would reach the fenceline (Table D.3-11). The maximum constituent concentration is reported for these constituents which will be used in the risk assessment for calculating risk. From these considerations, the list of constituents requiring aquifer (SWIFT) modeling and calibration during modeling is determined.

D.3.5 PERCHED GROUNDWATER CONCENTRATIONS

Theoretical perched groundwater concentrations are needed for the future exposure scenario to perched groundwater. These concentrations are reported on Table D.3-13 for Waste Pits 4, 5, 6 and the Burn Pit which, as discussed in Section D.3.3, have perched groundwater occurring in sand lenses beneath them. These values are the initial concentrations (Leachate B or Organic Leachate) for the entire list of CPCs determined in Section D.1.0 from the geochemical analysis. The list of CPCs represent a union of any constituent detected in any Operable Unit 1 waste area. These initial concentrations are used because they represent a conservative depiction of perched groundwater concentrations.

D.3.6 VADOSE ZONE MODELING

Vadose zone modeling is performed to estimate contaminant loading rates to the Great Miami Aquifer from a given source as a function of time. The overburden may have great capacity for immobilization and retardation of contaminants due to adsorption, precipitation, biodegradation, and radioactive decay. This capacity to prevent or slow the movement of contaminants to the aquifer is evaluated with respect to future risk.

The following criteria were used in selecting specific analytical models:

- Capability of treating adsorption, radioactive and organic decay, and longitudinal dispersion
- Capability of calculating concentrations over long time periods
- Availability of code

- Degree of code documentation
- Degree of code verification

The primary model selected is the ODAST model. To estimate time for source depletion and to calculate seepage velocity (required ODAST input parameters), leachate infiltration rates are calculated outside of ODAST. Either the HELP model (for covered pits) or an analytical solution (for pits with standing water) are utilized for calculating seepage velocities. These models are discussed below.

D.3.6.1 Models for Seepage Velocity

Description of HELP Model

To accomplish the simulation of the hydraulic system in Operable Unit 1, the HELP model is used to determine the infiltration rates through the waste units. The HELP model (US EPA 1984) is a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of a waste unit. The model accepts climatologic, soil, and design data and simulates a number of hydraulic processes including surface storage, runoff, infiltration, percolation, evapotranspiration, soil moisture storage, and lateral drainage. The systems that can be modeled by HELP include various combinations of vegetation, cover soils, waste cells, special drainage layers, and relatively impermeable barrier soils.

The HELP model is designed to perform water budget calculations for a system having as many as nine layers by modeling each of the hydrologic processes that occur. Each layer must be identified as either a vertical percolation, lateral drainage, waste, or barrier soil layer. The identification of each layer used in the model is critical because the program models water flow through the various types of layers in different ways. Runoff is computed using the Soil Conservation Service runoff curve number method by considering daily precipitation totals. Percolation and vertical water routing are modeled using Darcy's Law for saturated flow with modifications for unsaturated conditions. Evapotranspiration is estimated by a modified Penman method adjusted for limiting soil moisture conditions.

The HELP model output consists of input data echo, simulation results, and a summary. The input data echo includes all the information used for input including the values chosen from the model's built-in data base and any manually input data. Following the input data echo, the program produces a table of the daily results, monthly totals, and annual totals for each year if the options for detailed output are used. Following these outputs, the summary output is given. The summary includes average monthly totals, average annual totals, and peak daily values for the simulation variables. The average monthly totals reports precipitation, runoff, evapotranspiration, percolation through the base of each layer, and lateral drainage through each layer for a particular month for all the years of a simulation. The average annual total reports the values on an annual basis. The summary of peak daily values represents the maximum values that occurred on any day during the simulation period.

Description of Ponded Calculations

The HELP model could not perform calculations in cases where there was standing water. Since standing water is present at Waste Pits 5, 6, and the Clearwell, an alternate method was required for these ponded water cases.

A simple application of Darcy's Law in one dimension was used for these waste areas. This equation is:

$$q = K_{\text{eff}} * H/L$$

where

- q = flow rate (ft/d)
- K_{eff} = effective hydraulic conductivity (ft/d)
- H = total head = L + H_p (ft)
- L = length of saturated material (ft)
- H_p = depth of pond liquid (ft)

For this analysis, it was assumed that conditions beneath a waste pit with standing water would be saturated until the bottom of the first restrictive (low hydraulic conductivity) layer and would be unsaturated beneath this restrictive layer. For the Operable Unit 1 waste areas, this occurs at the bottom of the clay liner beneath the waste pits. The gradient was calculated as the difference in head between the water surface and the bottom of this layer divided by the length of saturated material. The effective hydraulic conductivity was calculated as the harmonic mean of the hydraulic conductivity of the waste and liner layers.

Infiltration Rate Results

HELP modeling for Operable Unit 1 included separate runs for Waste Pits 1 through 4 and the Burn Pit. In each simulation, the climatologic data of precipitation and mean monthly temperature were synthetically generated for Covington, KY. Average rainfall in the period was 40.64 inches/year.

The soil physical parameters and the design data used in the simulations were varied for each waste unit to reflect the varying conditions of each unit. These values were defined based upon the Waste Pit Contents Study (Parsons 1993). In general, layers were defined for an earth cover (if present), waste pit material, clay liner (if present), glacial till, and upper Great Miami Aquifer sands. Membrane liners were ignored for these simulations. Permeabilities were defined based upon engineering calculations (Parsons 1993). When permeabilities were not available, assumed values were utilized.

HELP was run to "steady state," that is, until successive simulations showed no appreciable change in soil moisture content in any of the layers. HELP results presented as infiltration rates (q) are shown on Table D.3-2. Results varied from 2.8 inches/year for the Burn Pit to 10.7 inches/year for Waste Pit 4.

For the ponded water cases of Waste Pit 5, 6, and the Clearwell, results of the Darcy calculation are shown on Table D.3-2. These values ranged from 10.1 inches/year (Clearwell) to 23.5 inches/year (Waste Pit 6). Higher values for the ponded cases are consistent with the fact that the head produced by the surface water would increase the infiltration rate.

D.3.6.2 Model for Solute Transport (ODAST)

ODAST Description

The model selected to evaluate flow in the vadose zone is ODAST (Javandel et al. 1984). ODAST, a one-dimensional analytical solution, is used for determining fate and transport of the constituents not previously screened out in the unsaturated zone. This computer code is based on the solution originally developed by Ogata and Banks (1961) and calculates the normalized concentrations of a given constituent in a uniform flow field from a source having a constant or varying concentration in the initial layer. ODAST evaluates the basic one-dimensional analytical solute transport equation as a function of seepage velocity, dispersion coefficient, source decay, retardation factor, depletion time, and source rate. ODAST has been extensively verified against STRIP1B (Batu 1989).

The ODAST model implements an analytical solution to the partial differential equation

$$D \frac{\partial^2 C}{\partial x^2} - V \frac{\partial C}{\partial x} - \lambda RC = R \frac{\partial C}{\partial t}$$

where

- C = solute concentration (mass/volume)
and with the constant coefficients
- D = dispersion coefficient (length²/time)
- V = seepage velocity (length/time)
- R = retardation factor (dimensionless)
- λ = solute decay factor (time⁻¹)

The solution must satisfy the initial and boundary conditions

$$C(x, 0) = 0$$

$$-D \frac{\partial C}{\partial x} + VC \Big|_{x=0} = \begin{cases} VC_0 e^{-\omega t} & 0 \leq t \leq \tau_0 \\ 0 & t > \tau_0 \end{cases}$$

where the constants

0129

$$\frac{\partial C}{\partial x} \Big|_{x \rightarrow \infty} = 0$$

C_o = initial source concentration (mass/vol) 1

α = source depletion factor (time⁻¹) 2

τ_o = source depletion time (time) 3

The solution is obtained using a Laplace transform technique and involves products of exponential and complementary error functions (Javandel et al. 1984). The solution for C is divided by C_o to yield normalized concentrations. 4 5 6

Because the coefficients in the governing equation are constant and the solution must satisfy a zero concentration gradient condition as x approaches infinity, ODAST is only strictly applicable to one-dimensional transport in homogeneous, semi-infinite media. However, the present application of ODAST is intended only to provide conservative estimates of aquifer mass loading histories. 7 8 9 10

ODAST is run only for those constituents that pass the travel time and initial concentration screening steps. Model runs can be executed for only one CPC at a time, and the solution may be applied over any arbitrary segment of a waste area that is judged to contain an unchanging subsurface. A superposition technique is used to combine calculations for the two homogeneous layers comprising the vadose zone conceptual model. The ODAST solution at the bottom of layer 1 is divided into 1000 small time steps and a layer 2 run is performed for each of these steps. Each of these layer 2 runs assumes no source decay, a recharge period 1/1000 of the total modeling time, and a source concentration equal to the averaged layer 1 solution for that time period. The solution at the bottom of layer 2 is obtained by summing the results of the 1000 layer 2 runs at specified time steps. For RI/FS modeling, concentrations are calculated up to 1,000 years, typically in steps of 20 years. Constituents that migrate quickly, such as organics, require smaller time steps for accurate representation of loading curves. 11 12 13 14 15 16 17 18 19 20 21 22

ODAST requires a formatted ASCII file containing the input parameters for a particular problem. This is the only input required. Likewise, output is contained in a single formatted ASCII file. The unit conventions for the input file parameters are: specified calculation times and source depletion time are expressed in years, all other parameters use days, and any consistent length scale may be used. 23 24 25 26

0130

The first parameters appearing in the input file are specifications of the values of the independent variables for which the calculations are desired. These include the number of x positions, number of times, and the actual x positions (measured positive downward from the top of the layer) and times. Because concentrations are required at the bottom of the layer, only one x position, representing layer thickness, is used. Layer thicknesses vary among and within the waste areas and are obtained from interpolated measurements at the FEMP. As previously stated, times up to 1,000 years in 20 year increments are normally used. The number of times may be greater and increments smaller if the constituent migrates rapidly.

The final line of the input file contains the waste area, solute, and medium dependent parameters. In order of appearance in the file, they are the dispersion coefficient, seepage velocity, retardation factor, source depletion time, solute decay factor, and source depletion factor.

Seepage velocity and the dispersion coefficient depend upon the characteristics of the waste area and the vadose zone medium. Seepage velocity is calculated as an empirical function of the percolation rate obtained from the HELP model, saturated hydraulic conductivity, and porosity (US EPA 1988). The dispersion coefficient is obtained as an empirical function of seepage velocity (Biggar and Nielsen 1976).

The retardation factor accounts for transport delays due to reversible reactions between the chemical constituent and the vadose zone solid matrix. It is thus dependent on both solute and medium characteristics, and is calculated as a function of the constituent's partitioning coefficient and the vadose zone bulk density and moisture content (Walton 1984 and Mills et al. 1985).

The solute decay factor is constituent dependent. This parameter accounts for biodegradation in organics and radioactive decay in radionuclides, and is zero for stable inorganics (ASI/IT 1992b).

Source depletion time and factor control the mass flux history of the constituent at the top of the modeled layer. As can be seen from the upstream boundary condition, source mass flux decays exponentially. To calculate depletion time and factor for the waste at the top of layer 1, the time dependent expression for mass flow from the source is integrated from zero to the source depletion time. This integral is equated to the depleted mass of the constituent to provide a single equation in two unknowns. A second equation is obtained by arbitrarily specifying a mass depletion fraction. This is the level (very close to, but less than one) at which the source is declared depleted; technically, the source is depleted only as time approaches infinity. As stated previously, depletion factor is zero and depletion time is 1/1000 of the total modeling time for the layer 2 runs.

For the 1,000-year scenario, the projected concentration of the leachate entering the Great Miami Aquifer beneath the waste area was calculated by multiplying the normalized concentration at the base of the lowest layer by the source term (initial contaminant concentration - Leachate B). The loading rates were calculated by multiplying the projected concentration beneath the waste area by the volumetric recharge rate from the source. The plots of loading rates versus time were then produced for the constituents which were projected to reach the aquifer within 1,000 years. The peak values in these plots were considered as the maximum loading rates to be observed in the aquifer for the contaminants over 1,000 years.

ODAST Modeling Results

Loading rates to the Great Miami Aquifer were estimated for each CPC for the Operable Unit 1 waste areas and for selected CPCs detected in the perched groundwater using ODAST. Technetium-99, uranium-234, uranium-235, uranium-238 and arsenic were selected from the perched groundwater CPCs they appear to present the highest risk based on the ratio of the maximum detected concentration and the 10^{-7} risk based or .1 Hazard Quotient concentrations. Table D.3-14 provides a summary of the loading times and rates for the CPCs which will reach the Great Miami Aquifer within 1,000 years. The loading rates were used as input data for SWIFT aquifer model to model the groundwater movement and solute transport in the Great Miami Aquifer. This table also presents the approximate number of years for the CPCs from Operable Unit 1 to reach the Great Miami Aquifer and the maximum concentrations of compounds in the leachate that would be expected before being diluted in the aquifer.

For the waste area source, Table D.3-14 shows that uranium-238 has the highest loading rate and loading concentrations at between 620 and 630 years. Uranium-234 and 235 also contribute significant loading and concentrations at these times. Boron and vinyl chloride have the highest loading and concentration of the inorganic and organic constituents respectively. Since different constituents contribute different proportions of risk based upon unit risk factors, concentrations need to be multiplied by risk factors to determine risks associated with a particular compound i.e., concentrations are not directly comparable from the standpoint of risk. To demonstrate the effect of loading for the perched groundwater source beneath Waste Pits 4, 5, 6 and the Burn Pit based on the highest risk, technetium-99, uranium-234, uranium-235, uranium-238 and arsenic were modeled. As shown in Table D.3-14, uranium-238 has the highest loading rate and loading concentrations between 530 and 540 years. When compared to loading concentrations from the waste area source, the radionuclide loading concentrations from the perched groundwater source are several orders of magnitude lower. Arsenic in the perched groundwater does not reach the Great Miami Aquifer in 1,000 years.

Loading rates of a constituent from ODAST to the aquifer from a given source vary over time. Typically, loading rates experience a mild increase representing the dispersion front followed by a sharp increase representing the principle breakthrough of the constituent. They can then stabilize or decrease depending upon the depletion time of the source. For a long depletion time the source remains active for a longer period during the simulation. The depletion rate is low for long depletion times, this ensures a mild change in the source term with time and helps to approach a steady-state condition within the simulation time of 1,000 years. For short depletion time, the source term vanishes earlier during the simulation period. For high depletion rates, the source term decreases faster during the simulation period. These factors cause an unsteady variation along with a sharp decline in the loading rates.

D.3.7 AQUIFER MODELING

Aquifer modeling is performed on both CPCs defined for the vadose zone pathway and CPCs from the surface water pathway. The derivation of the CPCs for the surface water pathway and the surface water modeling is presented in Section D.2.0.

D.3.7.1 Description of Model, Background, and Development

Groundwater modeling for the Operable Unit 1 risk analysis was performed with the calibrated groundwater flow model for the FEMP. This model utilizes the SWIFT code and was previously calibrated using groundwater elevations obtained during the April 1986 monitoring period. A brief summary of the calibration and the results of the calibration are presented in this section.

The groundwater modeling program was initiated to define groundwater transport in and around the FEMP. The selection, verification, calibration, and results of groundwater modeling are presented in two separate reports (IT 1990 and DOE 1990), and in the Groundwater Modeling Report - Summary of Model Development (DOE 1993). The groundwater model used in support of the risk analysis is a finite-difference computer model of groundwater flow and solute transport. The computer program used is SWIFT/386 Version 2.51. A comprehensive verification study of the SWIFT code has been completed and a report issued (IT 1990). A detailed presentation of the model, its development, and the baseline input data was issued as a part of the overall modeling report prepared under the RI/FS (DOE 1990) and revised and issued as a separate report (DOE 1993). Only the most pertinent information is presented here.

Steps in the development of the model for application to the FEMP have included:

- Construction and calibration of a regional, two-dimensional, steady-state groundwater flow model
- Construction and calibration of a regional, three-dimensional, steady-state groundwater flow model

0133

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- Application of a local, two-dimensional, analytical solute transport model to help strategize the numerical solute transport model
- Construction of a local, two-dimensional, transient solute transport model
- Construction and calibration of a local, three-dimensional, transient solute transport model with uranium concentration data from the monitoring wells

The regional model covers an area of 28.7 square miles (74.3 km²), including the FEMP, the Southern Ohio Water Company (SOWC) collector wells, and a portion of the Great Miami River. The regional model's grid spacing varies between 250 feet and 2,000 feet (76 m and 610 m), and has the closest grid spacing in the area of the SOWC collector wells. It was calibrated against field data using a steady-state flow condition and calibration results were incorporated into the local area model.

The local model covers a smaller area than the regional model and uses a tighter grid spacing, with grid cells 125 feet (38 m) on a side. The smaller grid was established to include the area of the existing uranium plume, and extends from the northern part of the FEMP to approximately 1,500 feet (460 m) north of the Great Miami River (Figure D.3-14). The grid size was selected based on the need to simulate a uranium dispersivity of 100 feet (30 m) longitudinally, which was the preferred value based on literature review (IT 1990). Using this dispersivity value, the grid size was selected to accommodate dispersivity values as low as 62.5 feet (19 m), or half the distance of the local grid area of 125 feet (38 m). The relationship between the local and regional models was established by imposing the steady-state flow field predicted by the regional model onto the local solute transport model.

The regional and local models each contain five layers. These layers are conceptually shown in Figure D.3-4. The uppermost two layers represent the upper and lower parts of the upper Great Miami Aquifer that underlies the area. The middle layer represents a clay interbed that is present in the immediate vicinity of the FEMP site, and the lowermost two layers represent the upper and lower parts of the lower Great Miami Aquifer. In regions where the clay interbed is not present, the middle layer has the same characteristics as the upper two layers. The layers extend laterally into bedrock to the edges of the buried valley that contains the aquifer. The number of aquifer cells in each layer was decreased with depth in the aquifer to simulate the narrowing bedrock valley. This was done using bedrock topography maps of the region and simulated the U-shaped buried valley which contains the Great Miami Aquifer.

Pumping wells are located in the area spanned by both the regional and local models. These include a FEMP production well (there are four total, but only one pumps significant quantities of water) and three industrial wells located south of the FEMP site in both models. Pumping from each of these wells was assigned to the proper cell and layer in the model. In addition, the regional model also

simulates the presence of two large capacity collector wells owned by the SOWC located by the Great Miami River. Although they are not directly included in the local model, they do influence its results by way of the boundary conditions brought in from the regional model.

The calibration of the groundwater flow model was performed by comparing hydraulic heads calculated by the model against heads measured in numerous monitoring wells throughout the FEMP and surrounding areas. This calibration was performed using the regional flow model. Reasonable estimates of hydraulic conductivity and recharge were initially input into the model and then varied within an acceptable range to adjust model-computed heads into agreement with observed monitoring well heads.

The model used varying hydraulic conductivity values for the five layers based on the results of the calibration. The uppermost and middle layers were assigned hydraulic conductivity values of 450 feet per day (140 m/day), and the lowermost layers used 600 feet per day (180 m/day). In addition, a portion of the middle layer which underlies the FEMP was assigned 0.0003 feet per day (9×10^{-5} m/day) as a hydraulic conductivity value to represent the clay interbed (as shown by geologic borings). This simulated the presence of a low permeability clay and created a semi-confining layer underneath part of the FEMP and its surrounding area. Vertical to horizontal hydraulic conductivity ratios were set for all layers at 0.1. Results of the recent South Plume pump test calculated aquifer values for vertical to horizontal ratios from 0.07 to 0.17 (i.e., over a range which includes this value) (Parsons 1993).

Recharge rates set as a result of the regional model calibration were assigned to several different zones. In areas where the sand and gravel aquifer is overlain by glacial overburden, a recharge of 6 inches per year (0.15 m/yr) was used. Regions where the Great Miami Aquifer is exposed at the surface use 14 inches per year (0.36 m/yr), with Paddys Run channel being assigned a value of 32 inches per year (0.81 m/yr) in the local model to simulate its increased infiltration. An additional region, the area covered by the FEMP was also included as a consequence of the sensitivity analysis. This region was assigned a value of 2 inches per year (0.05 m/yr) to simulate the developed nature of the site and the effects of storm water drainage into the storm sewer system.

Groundwater flow conditions simulated by the model were successful and reproduced the observed flow conditions throughout the study area. Based on water levels from 55 wells, the arithmetic mean residual (observed head minus calculated head at the monitoring well) for the calibrated flow model was 0.33 feet (0.1 m). The excellent match portrayed by this residual value is realized when compared to a total change in hydraulic head of approximately 20 feet (6.1 m) over the modeling area. The mean of the absolute values of the residuals was 1.08 feet (0.33 m), with a standard deviation of 1.36 feet (0.41 m). Water balances performed using the model showed total inflow and total outflow from the model to agree within 0.2 percent.

To maintain hydraulic similarity between the regional and local flow models, a computer program was used to check, cell by cell, the correspondence of heads in the local model with heads in the regional model. The program verified that the regional flow model calibration was preserved in the local model which was used for solute transport; thus, no new flow calibration was necessary. The local model used hydraulic parameters identical to those used in the calibrated regional model. Boundary conditions for the local model were set from corresponding cells in the regional model to maintain the hydraulic similarity.

D.3.7.2 SWIFT Modeling

The calibrated groundwater flow model for the FEMP is used to simulate the solute transport of the compounds in the Great Miami Aquifer. A constant loading period was defined for ODAST output for each constituent for the SWIFT modeling based upon source decay, retardation and constituent decay factors. Typically, a 5 year loading period was used for organics (low retardation factors) while a 20 year period was defined for radionuclides (high retardation factors). Loading rates for each period were calculated by averaging the results of the vadose zone modeling over the length of each period. In this way, total mass inflow into the aquifer was maintained. Compounds were simulated for a total of 1,000 years in the Great Miami Aquifer.

Loading rates were assigned to each of the potential source areas in the model and were adjusted to account for the varying surface area occupied by each waste area. Model source areas were calculated by dividing the area of the actual source by the area of a model grid cell, which is 125 feet (38 m) on a side (a total of 15,625 square feet [1450 m²]). This defined the number of cells needed for each source area in the model as shown in Table D.3-15. Cells in the model were then assigned to each source area to correspond with the physical location of the source. The loading rate for each compound was then divided by the number of model cells in each source area to derive the adjusted loading rate for each cell in the source area.

In the case of uranium-234, uranium-235, and uranium-238, all three uranium isotopes were modeled as one compound to simplify the modeling and to allow the use of the previously calibrated total-uranium solute transport model. Because the previous model utilizes total-uranium and because the uranium at the FEMP is mostly uranium-238 (approximately 99 percent by mass), this approach was used.

Initial background concentrations of each compound in the aquifer were set at zero. The model simulations for the Operable Unit 1 CPCs used dispersivity values of 100 feet (30 m) longitudinal and 10 feet (3 m) in the transverse direction. These values were determined during the solute transport calibration for uranium and are based on values taken from literature review (DOE 1990 and Walton 1985). Distribution coefficients (Kd) and decay factors for simulated compounds were also taken from literature review and are shown in Table D.3-16.

Model simulations were performed using SWIFT/386 on a Powerbox PC microcomputer. Simulation execution times varied between 18 and 37 hours and required extensive computing capacity. Output was written to a single file from which relevant data was extracted using data manipulation programs written for that purpose. Contour plots were made for selected constituents at different simulation times for CPCs from both the vadose zone and surface water pathways to represent plumes in space and plume changes over time. Contour plots are presented at 100 years, at the time of maximum concentration, and at 1,000 years.

Calibration to 2000 Series Wells Concentrations

As described above, modeled values are compared to monitored concentrations to confirm model predictions (see Section D.3.1.2). Calibration was performed to year 40 to reproduce approximate concentrations found in the aquifer. Table D.3-12 shows that calibration is required for barium, strontium-90, technetium-99 and uranium, based on these CPCs being present above background concentrations in the Great Miami Aquifer and reaching the fenceline within 1,000 years.

For barium, a source term of 0.2×10^{-1} lbs/day was added to 10 cells within Operable Unit 1 for the 30 year block of time. With this loading rate, a concentration of 0.37 ppm was modeled at the location of well 2027 compared to an average measured value of 0.4 ppm (based on 6 quarters of data 1991 and 1992). Since these values are within the same order of magnitude, calibration was considered complete.

For strontium-90, a source term of 0.44×10^{-12} lbs/day was added to 10 cells within Operable Unit 1 for the 30 year block of time. With this loading rate, a concentration of 5.3×10^{-9} ppb was modeled at the location of well 2019 compared to an average measured value of 5.25×10^{-9} ppb (based on 6 quarters of data 1991 and 1992). Since these values are within the same order of magnitude, calibration was considered complete.

For technetium-99, a source term of 0.128×10^{-4} lbs/day was added to 10 cells within Operable Unit 1 for the 30 year block of time. With this loading rate, a concentration of 1.78×10^{-1} ppb was modeled at the location of well 2019 compared to an average measured value of 1.92×10^{-1} ppb (based on 6 quarters of data 1991 and 1992). Since these values are within the same order of magnitude, calibration was considered complete.

For uranium, a source term of 0.2×10^{-3} lbs/day was added to 10 cells within Operable Unit 1 for the 30 year block of time. With this loading rate, a concentration of 2.6 ppb was modeled at the location of well 2019 compared to an average measured value of 2.6 ppb (based on 6 quarters of data 1991 and 1992). At well 2021, a modeled value of 2.25 ppb compared to a measured value of 5.7 ppb. Since these values are within the same order of magnitude, calibration was considered complete.

0610

Vadose Zone Pathway SWIFT Results

Table D.3-17 summarizes the SWIFT modeling results. This table shows the time and value of maximum concentration for each of the modeled constituents for both the waste area and perched groundwater sources. In addition, concentrations, based on monitoring data, are presented for constituents found in groundwater. These represent present day (model year 40) concentrations of these constituents. By comparing Tables D.3-14 and D.3-17, constituents are typically predicted to decrease 2 orders of magnitude from the vadose zone concentration to the Great Miami Aquifer. From Table D.3-17, it is seen that the uranium isotopes for the waste area source have the highest modeled concentrations in the Great Miami Aquifer. Uranium-238 is more than 2 orders of magnitude more than uranium-235 and almost 4 orders of magnitude greater than the next highest constituent, vinyl chloride. Even with variable unit risk factors, uranium-238 will dominate the risk.

Based on the previous discussion, the time of maximum risk on-site and off-site risk is determined by the maximum uranium-238 for the waste area source. These concentrations occur at 630 years (on-site) and 680 years (off-site). For the perched water source, the time of maximum risk on-site and off-site risk is also determined by the maximum uranium-238. These concentrations occur at 540 years (on-site) and 690 years (off-site). Because uranium isotopes have the same retardation factors, the maximums for uranium-234 and 235 also occur at these times. Tables D.3-18 and D.3-19 present the CPC concentrations at these years at the maximum on site location and maximum off site location. Again it is seen that the uranium isotopes especially uranium-238 dominate the concentrations and thus the risks at these locations and times. Appendix E will calculate the total risk based upon these concentrations.

Figures D.3-14 through 22 illustrate the concentrations in the groundwater at the three selected time intervals for uranium, cyanide and tetrachloroethene due to loading from the Operable Unit 1 source areas. Plume maps of these constituents are presented to provide spatial distributions of representative constituents as they migrate through time. From Figures D.3-14 through 22, it can be observed that the contaminant plumes are moving towards the east and southeasterly directions. This flow direction corresponds to the model flow field and is influenced by the high capacity SOWC water supply wells located east of the facility. For uranium, (Figures D.3-15, 16, and 17), minimal concentrations are predicted after 100 years. A maximum is reached in 630 years which slowly declines to 1,000 years (compare Figures D.3-16 and 17). The cyanide plots (Figures D.3-18, 19, and 20) all show similar trends suggesting a small but constant source term. The tetrachloroethene plots (Figures D.3-21, 22, and 23) also show similar trends over time. A "steady state" equilibrium is reached for the tetrachloroethene plume based upon a continuing source and a high decay rate.

Surface Water Pathway SWIFT Results

Section D.2.0 modeled runoff and stream concentrations. Because Paddys Run lies directly in contact with the Great Miami Aquifer over a portion of its course, a contaminant migration pathway exists into the aquifer through its streambed. Migration of contaminants in surface runoff to Paddys Run from the surface soil in the Operable Unit 1 waste areas and from Paddys Run to the Great Miami Aquifer has been designated the surface water to groundwater pathway. CPCs that follow the surface water pathway to the Great Miami Aquifer are first screened to remove constituents that pose insignificant risk. This screening is performed by taking the contaminant concentration in the runoff effluent (C_e) from MUSLE, and applying a Great Miami Aquifer dilution factor to this concentration to determine a theoretical Great Miami Aquifer concentration. This theoretical Great Miami Aquifer concentration was then compared to 10^{-7} risk based concentrations for carcinogens or 0.1 Hazard Quotient concentrations for non-carcinogens. These screening concentrations are derived by dividing the 10^{-6} risk based concentrations or Hazard Quotient of 1 concentrations for tap water (EPA 1993) by 10. If theoretical Great Miami Aquifer concentrations are below the screening concentrations then the constituent is screened out and is not modeled in the aquifer (Table D.2-5). One-hundred percent of the runoff effluent volume is assumed to flow to the Great Miami River, and 30 percent of the runoff effluent volume is assumed to infiltrate to the Great Miami Aquifer through Paddys Run during storm events.

Since Paddys Run exfiltrates to the Great Miami Aquifer, the constituents that passed the surface water screening (see Section D.2.0) are modeled with SWIFT. Constituents requiring modeling include arsenic, technetium-99 and uranium-234 and 238 isotopes (see Table D.2-5).

Table D.3-20 summarizes the results of the SWIFT modeling for these surface water constituents presenting the time and maximum concentrations. The radionuclides all show maximum concentrations within 40 years. Arrival times are fast since there is a direct connection between Paddys Run and the aquifer. Maximums are reached quickly because the source term maximizes at the beginning and depletes over time. Because of their higher K_d s, arsenic and lead take a longer time to reach a maximum concentration. Mass of constituents entering the aquifer from the surface water are initially adsorbed. Like the vadose zone pathway, uranium-238 has the highest concentration of the modeled constituents by five orders of magnitude over uranium-234 and 4 orders of magnitude over arsenic.

Figure D.3-24 shows the total uranium plume from the surface water loading at the time of maximum concentration of 10 years at coordinates N481,311, E1,377,790. This figure shows a plume centered on Paddys Run with primary transport to the east and to the south. Some western transport is also shown caused by mounding and dispersion. This figure shows the general trends of how the south plume could have been created by exfiltration from Paddys Run.

8810

0139

D.3.8 UNCERTAINTY IN MODELING RESULTS

The fate and transport modeling performed for Operable Unit 1 is subject to uncertainty and variability due to factors such as the lack of compound specific characterization data, the inability of the models to simulate natural systems with 100 percent accuracy, and the assumptions for future site conditions for the waste units. Of these factors, the assumptions made for the future conditions of the waste units have the most impact on the modeling results. The waste units are all assumed to release contaminants to the environment without future maintenance. This is a worst case scenario and thus yields higher contamination levels than would be considered if a vegetative cover or cap was constructed. However, this type of assumption is the primary premise in performing a baseline assessment and the most conservative for the purpose of evaluating the risk from the groundwater pathway.

The inherent assumptions built into the models and the assumptions made to develop input parameters for the models also have an impact on the final results. The major uncertainty in the analysis is the estimation of parameters related to the attenuation and retardation of constituents. Based upon the data available, a conservative approach was used which may overestimate the concentration of the leachate. The assumptions of total contact between the waste and the leaching fluid and no containment of the leachate concentrations will produce higher concentrations than would be anticipated under actual conditions.

The following sections discuss uncertainty associated with the different models used in the fate and transport modeling.

D.3.8.1 HELP Model

The HELP model is mainly sensitive to the parameters used to define evapotranspiration and runoff. The majority of water exiting the system is lost through these two mechanisms and thus the remaining water becomes the seepage passing through the waste unit. Evapotranspiration is controlled by the plant cover type used, which was assumed to be bare ground for the Operable Unit 1 simulations. This would in fact cause a large decrease in contaminant seepage and loadings if vegetative cover were established, as the amount of water available for seepage would decrease. As this is currently not the case, the present results from the HELP model are more conservative.

Runoff in the HELP model is controlled by the Soil Conservation Study runoff curve number used, which in turn is derived from the ground type, vegetation type, and land use. If any of these factors are incorrect, available water for seepage could change and thus loading to the aquifer would change.

Uncertainty was also involved in the computation of seepage flow rates for the glacial till and the unsaturated sand and gravel layer. The unsaturated seepage flow rate is a function of the unsaturated hydraulic conductivity which depends on parameters such as porosity, residual saturation, and pore size

distribution index. All of these parameters vary in a physical formation matrix and thus cannot be fully defined for use in a numerical model. However, the sensitivity of HELP to hydraulic conductivity was examined. A typical HELP run for the production area of the site had four layers: (1) earth cover, (2) fractured brown clay, (3) till or gray clay, and (4) unsaturated aquifer. Thicknesses were 0.5, 15, 17, and 35 feet respectively. The lowest hydraulic conductivity was that of the till layer. Table D.3-21 illustrates the effect of changing this conductivity on seepage rate.

It is apparent that a reduction of over 2 orders of magnitude is necessary to cause a significant reduction in the seepage velocity. Apparently the rate of 10.92 inches/year is limited by other factors (i.e., that is all the water that is available for seepage). Consequently, one would expect that the rate would not increase significantly with increases in hydraulic conductivity.

A sensitivity analysis of effect on seepage rate of change in conductivity values was also performed using a different stratigraphy; that of Waste Pit 1. Five layers were present (1) earth cover - 0.5 feet, (2) Pit 1 Waste - 18 feet, (3) clay liner - 11 feet, (4) till - 2 feet, and (5) unsaturated aquifer - 24.3 feet. Conductivities of each of these layers were changed in order of magnitude steps, both up and down. The results are illustrated in Table D.3-22.

It is apparent that for Pit 1 large changes in all conductivities will affect the seepage rate. Reduction in the conductivity would cause an almost proportional reduction in seepage rate. An increase of 10 caused an increase by a factor of 3+ so that it is apparent that other factors (evapotranspiration, etc.) are becoming important. The seepage rate would certainly be expected to be bounded by these values.

D.3.8.2 ODAST Model

Sensitivity analyses were conducted on the vadose zone model ODAST by varying the Darcy velocity, the longitudinal dispersivity, and the layer thickness within the model to determine their impacts on the loading curves generated by the models. Data from a waste unit was used as a baseline for comparison and an unretarded, nondecaying contaminant was used. Longitudinal dispersivity, Darcy velocity, and layer thickness were all varied by a factor of two by both doubling and halving each of the parameters while all other input was held constant. ODAST was used to evaluate the impacts of each of these parameters on final modeling results. The results of these analyses are presented in Figures D.3-25, D.3-26, and D.3-27.

All three figures illustrate that for a given source loading rate, the peak concentration reached for a nondecaying solute is the same regardless of the flow system used. This is shown by the peak loadings reached by the contaminant, which is 100 ppb for all cases studied. The main influence noted in all three cases has to do with the time required for maximum loading to occur at the base of the vadose zone. Longitudinal dispersion (Figure D.3-25) has a negligible impact on the time for loading to reach the aquifer and the vadose models are not sensitive to its value. The models are

October 12, 1993

4787
sensitive to both Darcy velocity (Figure D.3-26) and layer thickness (Figure D.3-27) as these both directly control the transport time required to pass through the vadose zone. Doubled layer thicknesses or halved Darcy velocities cause a significant increase in the time required for contaminant to reach the aquifer and for maximum loading to occur. Likewise, halving the layer thicknesses and doubling the Darcy velocity causes a decrease in the times.

The impact of the Darcy velocity and layer thickness on the models is somewhat limited due to the derivation of the parameters themselves. Layer thicknesses were derived from Operable Unit 1 boring data which should not vary over a large range within the operable unit. Darcy velocity is a function of the seepage rate, calculated by the HELP model, and the formation porosity, which is fairly well defined for the media simulated by the models.

A parameter specific sensitivity analysis was conducted for uranium-234, as a part of the modeling analysis to observe the variation of the modeling results by changing the values of certain parameters. The sensitivity runs were performed by increasing and decreasing hydraulic conductivity, porosity, and retardation factor from the estimated values in a series of order-of-magnitude steps in the range of known site values. Hydraulic conductivity is a very important flow parameter. It is used as a direct input into the seepage velocity calculation, moreover, hydraulic conductivity is also a controlling factor in determining the seepage flow under both saturated and unsaturated conditions as described in the previous section.

Results indicate that the variation of hydraulic conductivity only affects the arrival time of the contaminant (uranium-234), however there is no significant change in the peak concentration. The arrival times of the contaminant in the aquifer were estimated at 100 and 540 years, respectively, due to increase and decrease in the hydraulic conductivity value by 1 order of magnitude from the estimated value. Further decreasing the hydraulic conductivity by 2 orders of magnitude, the arrival time was delayed to 2,200 years. Sensitivity runs conducted by varying porosity (increasing as well as decreasing porosity by 30 percent) had no significant effect either on the arrival time or peak concentration. Results also indicate that the variation of distribution co-efficient affects the arrival time, whereas the peak concentration remains unchanged. Arrival times, for the sensitivity runs performed by decreasing and increasing distribution co-efficient by 1 order of magnitude were 40 years and 1,200 years respectively.

From sensitivity analysis, it was seen that the variation of different parameters affects the arrival time of the contaminant, however, there is no significant change in the peak concentration. It was observed that the peak concentration for uranium was always within 1 order of magnitude when steady state or peak concentration was reached.

When decay is combined with low seepage velocities and/or retardation due to adsorption, the contaminant concentration at the Great Miami Aquifer is significantly reduced. However, the difference between the peak concentrations reaching the aquifer for low and high seepage velocities is sensitive to whether the contaminant concentration reached a steady state. For any contaminant, if the steady state condition was reached for both low and high seepage flow velocities, the peak concentrations differ less compared to other constituents that did not reach a steady state concentrations at the aquifer within the simulation period of 1,000 years.

The movement of organic constituents to the Great Miami Aquifer is greatly impeded by high biodegradation rates. For low seepage velocities and dispersion coefficients, the transport process is delayed and more time is available for degradation of the organic chemicals. Thus for organic chemicals, the peak concentrations were several orders of magnitude lower (or zero) with low-end as compared to high-end seepage velocities and dispersion coefficients.

The range of hydraulic conductivities at a site is constrained by the geology. Nevertheless, the reasonable range of hydraulic conductivities at a site permits a high degree of variability in contaminant transport.

D.3.8.3 SWIFT Model

Like the vadose zone models, SWIFT is mostly influenced by the solute transport parameters it uses to simulate contaminant movement through the aquifer. Of these, retardation is the least well defined and has the most impact on the fate of contaminants in the groundwater. Calibration of the SWIFT model for uranium was performed as part of the RI/FS process. The SWIFT flow model was calibrated by comparing hydraulic heads calculated by the model against heads measured in numerous monitoring wells throughout the FEMP and surrounding areas. The flow calibration is described in Section 3.7-1. The SWIFT solute transport model was calibrated by simulation of uranium transport in the Great Miami Aquifer (IT 1990a) over the period of operation at the FEMP. A portion of this calibration involved testing uranium retardation values to determine which value fit historical loading data and present day groundwater concentration data most accurately. Uranium retardation factors below 4 were found to transport uranium too quickly through the system and thus did not match historical data. Retardation factors above 15 were found to not match present day uranium distributions without large aquifer dispersion values, which were felt to be unrealistic. Consequently, a retardation factor of 12 was found to give the best match for uranium during the modeling process, which also fell within the range of the geochemical studies performed for uranium at the FEMP (IT 1989). This same value was used in uranium fate and transport modeling.

Two SWIFT sensitivity runs were completed with parameters chosen to maximize dilution and dispersion (Run #1) and to minimize dilution and dispersion (Run #2). The retardation factor of 12 (corresponding to K_d of 1.4 ml/g) is considered to be a conservatively low value since most

October 12, 1993

~~4787~~

experimental data for FEMP and other locations indicate higher values. This value was used in Run #1, SWIFT layers 1 and 2. Other parameter values layers 1 and 2 for Runs #1 and #2 were chosen to represent a reasonable range that might be expected in the aquifer sand and gravel layers. Nominal values for other layers were retained. Table D.3-23 illustrates the input parameters and results for these runs.

These results indicate that almost an order of magnitude variation in maximum concentration could be expected within the range of variation expected for site parameters. Note however that the plume spread is more significant with almost a factor of 100 variation in size for the area within the 1 ppb contour. Note that while Run #2 has higher concentrations, the 1 ppb contour is contained in a small area underneath the site. The time of occurrence for peak concentrations for Run #2 is also extended beyond 1,000 years.

As described in Section D.3.1.2, "direct leak" terms have now been incorporated into the calibration process so that a better match of early concentrations of uranium and consideration of other constituents with limited groundwater monitoring data are possible. The major parameter affecting solute transport is retardation. Higher retardation factors delay the appearance of a concentration peak at a receptor almost proportionately. Experimental determination of retardation factors for CPCs, which have relatively large source terms and are relatively toxic is an important factor in reducing uncertainty in solute transport.

REFERENCES

- ASI/TT, Advanced Sciences, Inc./International Technologies Corporation, October 1992. Work Plan Addendum. Fernald, OH.
- Batu, V., 1989. "A Generalized Two-Dimensional Analytical Solution for Hydrodynamic Dispersion in Bounded Media with the First-Type Boundary Condition at the Source," Water Resources Research, Vol. 25, No. 6, pp. 1125-1132.
- Barari, A. and L. S. Hedges, 1985. "Movement of Water in Glacial Till." International Association of Hydrogeologists, Memoirs, Vol. XVII, Part 1. Proceedings, Hydrogeology of Rocks of Low Permeability. Tucson, AZ.
- Biggar, J. W. and D. R. Nielsen, 1976. "Spatial Variability of the Leaching Characteristics of a Field Soil." Water Resources Research, Vol 12, No. 1.
- Brenner, H., 1962. "The Diffusion Model of Longitudinal Mixing in Beds of Finite Length Numerical Values." Chemical Engineering Science, Vol. 17, pp. 229-243.
- Brockman, S. C., 1988. "Glacial Geologic Mapping in Hamilton County, Ohio, Report of Progress on the Final Phase." Ohio Department of Natural Resources, Division of Geological Survey.
- Cravens, S. J. and L. C. Ruedisili, 1987. "Water Movement in Till of East-Central South Dakota." Groundwater, Vol. 25, No. 5.
- Dove, G. D. and S. E. Norris, 1951. "Conditions Governing the Occurrence of Groundwater in the Fernald Area, Ohio, with Reference to the Possibilities of Contamination by Disposal of Chemical Wastes." U.S. Geological Survey, Groundwater Branch. Columbus, OH.
- Fetter, C. W., 1989. Applied Hydrogeology, Second Ed. Columbus, OH: Charles E. Merrill Publishing Company.
- Freeze, R. A. and J. A. Cherry, 1979. Groundwater. New York: Prentice-Hall.
- Geotrans, Inc., 1987. "The Sandia Waste-Isolation Flow and Transport Model for Fractured Media, SWIFT III, Release 2.32." Herndon, VA.
- Grisak, G. E., J. A. Cherry, J. A. Vonhof, and J. P. Blumele, 1976. "Hydrogeologic and Hydrochemical Properties of Fractured Till in the Interior Plains Region: in Glacial Till, An Interdisciplinary Study." The Royal Society of Canada, Special Publications, No. 12, Robert F. Legget, ed. Ottawa, Ontario.
- Heath, R. C., 1983. "Basic Groundwater Hydrology." U.S. Geological Survey, Water Supply Paper 2220. Reston, VA.
- Hendry, M. J., 1988. "Hydrogeology of Clay Till in a Prairie Region of Canada." Groundwater, Vol. 26, No. 5.
- Howard, P. H., R. S. Boethling, W. F. Jarvis, W. M. Meylan and E. M. Michalenko, 1991. Environmental Degradation Rates. Chelsea, MI: Lewis Publishers, Inc.

- IT Corporation, 1989. "Geochemical Program : Issues 3 and 5." Prepared for U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN. 1
2
- IT Corporation, 1990a. "Flow and Solute Transport Computer Code Verification." Prepared for U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN. 3
4
- IT Corporation, 1990 b. "FMPC Groundwater Report." Prepared for U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN. 5
6
- IT Corporation, November 7, 1990c. Memorandum from Sirous H. Djafari of IT for distribution, Subject - "Determination of Hydraulic Conductivity of Till and Unsaturated Great Miami Aquifer Units." 7
8
9
- Javandel, I., C. Doughty, and C. F. Tsang, 1984. "Groundwater Transport: Handbook of Mathematical Models." American Geophysical Union Water Resources Monograph Series 10. Washington, DC. 10
11
12
- Mills, W. B., J. D. Dean, D. B. Porcella, S. A. Gherini, R. J. M. Hudson, W. E. Frick, G. L. Rupp, and G. L. Bowie, 1982. "Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants: Parts 1, 2, and 3." U.S. EPA Environmental Research Laboratory, Office of Research and Development. Athens, GA, EPA-600/6-82-004 a, b, c. 13
14
15
16
- Mills, W.B., D.B. Porcella, M.J. Unga, S.A. Gherini, K.V. Summers, Lingfung Mok, G.L. Rupp, G.L. Bowie, and D.A. Haith, 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Groundwater. US EPA Environmental Research Laboratory, Office of Research and Development. EPA/600/6-85/002a. Athens, GA. 17
18
19
20
- Morris, D. A. and A. I. Johnson, 1967. "Summary of Hydrologic and Physical Properties of Rock and Soil Materials, as Analyzed by the Hydrologic Laboratory of the U.S. Geological Survey." U.S. Geological Survey, Water-Supply Paper 1839-D. 21
22
23
- Rajendran, R., J. B. Patro, A. K. Sridharan, and M. Sampath, 1979. "Solvent Extraction of Uranyl Nitrate with Tributyl Phosphate," in Symposium on Solvent Extraction of Metals. Bombay, India: Department of Atomic Energy. 24
25
26
- Ogata, A. and R. B. Banks, 1961. "A Solution of the Differential Equation of Longitudinal Dispersion in Porous Media." U.S. Geological Survey, Professional Paper 411-A, Reston, VA. 27
28
- Parsons, 1993. "South Plume Removal Action Pumping Test Report, Operable Unit 5, Project Order 37." Fernald Environmental Management Project, Fairfield, Ohio. 29
30
- U.S. Department of Energy, 1990. "Groundwater Report - Draft." Prepared for U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN. 31
32
- U.S. Department of Energy, 1992. "Final Draft Risk Assessment Work Plan Addendum." Fernald Environmental Management Project, Remedial Investigation and Feasibility Studies, Fernald, OH. 33
34
- U.S. Department of Energy, 1993a. Groundwater Modeling Report - Summary of Model Development. Fernald, OH. 35
36

- U.S. Department of Energy, March 1993b. "Sitewide Characterization Report." FEMP, SWCR-6, Final. 1
- U.S. Department of Energy, May 1993c. "Characterization of Background Water Quality for Streams and Groundwater." Fernald, OH, Draft. 2
- U.S. Environmental Protection Agency, 1984. "The Hydrologic Evaluation of Landfill Performance (HELP) Model." EPA/530-SW-84-009. Washington, DC: US EPA, Office of Solid Waste and Emergency Response. 3
- U.S. Environmental Protection Agency, 1985. "Water Quality Assessment," EPA/600/6-85/002b. Athens, Georgia: Office of Research and Development. 4
- U.S. Environmental Protection Agency, 1987. "Low-Level and NARM Radioactive Wastes, Model Documentation PRESTO-EPA-POP, Volume 1, Methodology Manual; Volume II, Users Manual." EPA/520/1-87-024-1 and 2. Washington, DC: EPA, Office of Radiation Programs. 5
- Walton, W. C., 1970. Groundwater Resource Evaluation. McGraw-Hill. 6
- Walton, W. C., 1984. Practical Aspects of Groundwater Modeling - 2nd Edition. Worthington, OH: National Water Well Association. 7

3411

0147

TABLE D.3-1

WASTE AREA PHYSICAL PARAMETERS FOR OPERABLE UNIT 1 MODELING

Location	Area		Volume of Waste Material		Dry Density
	(m ²)	(ft ²)	(m ³)	(yd ³)	(kg/m ³)
Pit 1	7,682	82,691	37,083	48,500	1,660
Pit 2	4,172	44,901	18,503	24,200	1,310
Pit 3	22,422	241,347	156,055	204,100	1,330
Pit 4	7,785	83,799	42,130	55,100	1,830
Pit 5	14,965	161,077	74,854	97,900	958
Pit 6	3,011	32,410	7,340	9,600	1,550
Burn Pit	2,019	21,732	23,167	30,300	1,130
Clearwell	2,737	29,461	2,829	3,700	2,650

TABLE D.3-2
VADOSE ZONE MODEL INPUT PARAMETERS
OPERABLE UNIT 1

Waste Unit	Layer	Thickness (ft)	K_v (ft/day)	q (ft/day)	V_x (ft/day)	D_x (ft ² /day)
Waste Pit 1	1	2.0	1.140×10^{-2}	7.500×10^{-4}	2.453×10^{-3}	8.231×10^{-4}
	2	24.3	4.500×10^1	7.500×10^{-4}	5.176×10^{-3}	1.052×10^{-3}
Waste Pit 2	1	13.0	1.140×10^{-2}	1.380×10^{-3}	4.407×10^{-3}	9.855×10^{-4}
	2	20.0	4.500×10^1	1.380×10^{-3}	9.016×10^{-3}	1.398×10^{-3}
Waste Pit 3	1	0.0				
	2	23.7	4.500×10^1	2.240×10^{-3}	1.401×10^{-2}	1.872×10^{-3}
Waste Pit 4	1	13.0	1.860×10^{-2}	2.440×10^{-3}	7.768×10^{-3}	1.283×10^{-3}
	2	21.7	4.500×10^1	2.440×10^{-3}	1.514×10^{-2}	1.983×10^{-3}
Waste Pit 5	1	13.3	1.830×10^{-3}	3.670×10^{-3}	1.149×10^{-2}	1.630×10^{-3}
	2	23.0	4.500×10^1	3.670×10^{-3}	2.196×10^{-2}	2.665×10^{-3}
Waste Pit 6	1	15.9	1.670×10^{-2}	5.360×10^{-3}	1.648×10^{-2}	2.114×10^{-3}
	2	24.3	4.500×10^1	5.360×10^{-3}	3.099×10^{-2}	3.607×10^{-3}
Burn Pit	1	12.9	1.410×10^{-2}	6.430×10^{-4}	2.133×10^{-3}	7.976×10^{-4}
	2	21.7	4.500×10^1	6.430×10^{-4}	4.500×10^{-3}	9.935×10^{-10}
Clearwell	1	0.0				
	2	23.7	4.500×10^1	2.290×10^{-3}	1.429×10^{-2}	1.900×10^{-3}

K_v - vertical hydraulic conductivity
 q - vertical flow rate
 V_x - vertical seepage velocity
 D_x - longitudinal dispersion coefficient

TABLE D.3-3
MEDIA PARAMETERS FOR VADOSE ZONE MODEL
OPERABLE UNIT 1

Parameter	Vadose Zone	
	Layer 1 ^a	Layer 2 ^b
Porosity (%)	34	39
Specific yield (%)	6	25
Bulk density (g/cc)	1.78	1.60
Field capacity (%)	28	14
Organic content (%)	1	0.5
Fines passing less than 200 mesh (%)	70	16
Moisture content (%)	34 ^c	26 ^d

^aLayer 1 consists of a clay-rich till interbedded with glaciofluvial sand and gravel stringers.

^bLayer 2 consists of well-sorted sand and gravel outwash deposits existing above the Great Miami Aquifer.

^cLayer 1 is assumed saturated.

^dAverage between porosity and field capacity.

4783

TABLE D3-4
RETARDATION FACTORS AND DECAY CONSTANTS
FOR RADIONUCLIDES AT OUI

Constituent	Retardation Factor Vadose 1	Retardation Factor Vadose 2	Radioactive Decay Constant (Day ⁻¹)
Cs-137	9.49×10^3	8.43×10^3	6.294×10^{-5}
Np-237	2.89×10^2	3.18×10^1	8.874×10^{-10}
Pu-238	8.91×10^3	6.16×10^2	2.164×10^{-5}
Pu-239/240	8.91×10^3	6.16×10^2	7.870×10^{-8}
Ra-226	3.65×10^3	6.53×10^2	1.187×10^{-6}
Ru-106	4.19×10^3	3.39×10^2	1.890×10^3
Sr-90	5.34×10^1	1.64×10^1	6.640×10^{-5}
Tc-99	1.62×10^0	1.43×10^0	8.916×10^{-9}
Th-230	3.04×10^4	1.97×10^4	2.466×10^{-3}
Th-232	3.04×10^4	1.97×10^4	9.926×10^{-4}
U-234	6.38×10^1	1.01×10^1	7.767×10^{-9}
U-235	6.38×10^1	1.01×10^1	2.698×10^{-12}
U-238	6.38×10^1	1.01×10^1	4.250×10^{-13}

0151

TABLE D.3-5
RETARDATION FACTORS FOR
INORGANIC COMPOUNDS AT OU1

Inorganics	Retardation Factor Vadose 1	Retardation Factor Vadose 2
Antimony	1.05×10^3	1.23×10^3
Arsenic	1.31×10^3	2.78×10^3
Barium	5.97×10^3	1.24×10^2
Beryllium	6.81×10^3	1.54×10^3
Boron	1.67×10^1	1.95×10^1
Cadmium	2.62×10^3	7.48×10^1
Chromium	7.86×10^3	4.32×10^2
Cobalt	2.88×10^3	3.70×10^2
Copper	6.56×10^2	2.16×10^2
Lead	1.57×10^4	2.35×10^2
Manganese	9.44×10^2	3.09×10^2
Mercury	5.34×10^1	6.25×10^1
Molybdenum	4.73×10^2	6.25×10^1
Nickel	3.41×10^3	2.46×10^3
Selenium	3.88×10^3	9.24×10^2
Silver	9.44×10^2	5.55×10^2
Thallium	7.86×10^3	9.23×10^3
Tin	3.40×10^3	4.00×10^3
Vanadium	5.24×10^3	1.23×10^3
Zinc	1.26×10^4	1.23×10^3

4787

TABLE D.3-6

RETARDATION FACTORS AND BIODEGRADATION COEFFICIENTS
FOR ORGANIC COMPOUNDS AT OUI

Organics	Retardation Factor Vadose 1	Retardation Factor Vadose 2	Organic Decay Constant (Day ⁻¹)
1,2,3,7,8-Pentachlorodibenzofuran	1.66×10^4	4.20×10^3	NA ^a
2,3,4,7,8-Pentachlorodibenzofuran	1.66×10^3	4.20×10^3	NA
4-Nitroaniline	NA	NA	
4-Nitrophenol	3.04×10^0	1.52×10^0	7.07×10^{-2}
4,4-DDT	3.89×10^4	9.85×10^3	1.20×10^{-4}
Acenaphthene	2.10×10^2	5.39×10^1	1.70×10^{-3}
Anthracene	7.03×10^2	1.79×10^2	3.80×10^{-4}
Aroclor-1248	1.41×10^4	3.57×10^3	NA
Aroclor-1254	2.68×10^4	6.80×10^3	NA
Aroclor-1260	3.24×10^4	8.20×10^3	NA
Benzo(a)anthracene	1.00×10^4	2.54×10^3	2.50×10^{-4}
Benzo(a)pyrene	2.40×10^4	6.07×10^3	2.50×10^{-3}
Benzo(b)fluoranthene	9.33×10^4	2.36×10^4	2.80×10^{-4}
Benzo(g,h,i)perylene	4.27×10^5	1.08×10^5	2.70×10^{-4}
Benzo(k)fluoranthene	1.74×10^5	4.40×10^4	8.0×10^{-5}
Chrysene	1.00×10^4	2.54×10^3	1.70×10^{-4}
Cyanide ^b	1.22×10^0	1.11×10^0	9.50×10^{-4}
Dibenzo(a,h)anthracene	2.34×10^4	5.93×10^3	1.80×10^{-4}
Dichlorodifluoromethane	4.63×10^0	1.92×10^0	9.50×10^{-4}
Fluoranthene	5.37×10^3	1.36×10^3	3.90×10^{-4}
Fluorene	3.77×10^2	9.63×10^1	2.90×10^{-3}
Heptachlorodibenzo-p-dioxin	2.63×10^5	6.65×10^4	NA
Heptachlorodibenzofuran	1.66×10^4	4.20×10^3	6.19×10^{-3}
Hexachlorodibenzo-p-dioxin	2.63×10^5	6.65×10^4	NA
Hexachlorodibenzofuran	1.66×10^4	4.20×10^3	NA
Ideno(1,2,3-cd)pyrene	1.15×10^6	2.90×10^5	2.40×10^{-4}
Naphthalene	5.87×10^1	1.56×10^1	2.69×10^{-3}

TABLE D.3-6
(Continued)

Organics	Retardation Factor Vadose 1	Retardation Factor Vadose 2	Organic Decay Constant (Day ⁻¹)
Octachlorodibenzo-p-dioxin	2.63×10^5	6.65×10^4	NA
Octachlorodibenzofuran	1.66×10^4	4.20×10^3	6.19×10^{-3}
Pentachlorophenol	2.56×10^3	6.49×10^2	4.60×10^{-4}
Phenanthrene	7.29×10^2	1.85×10^2	8.70×10^{-4}
Pyrene	3.79×10^3	9.60×10^2	9.00×10^{-5}
Tetrachlorodibenzofuran	1.66×10^4	4.20×10^3	NA
Tetrachloroethene	9.51×10^0	3.15×10^0	4.20×10^{-4}
Vinyl chloride	1.10×10^0	1.03×10^0	2.40×10^{-4}

^aNA denotes not available.

^bCyanide is an inorganic compound but it has an organic decay constant.

8011

TABLE D.3-7

SCREENING SUMMARY OF POTENTIAL CONSTITUENTS OF CONCERN FOR OPERABLE UNIT 1

Potential Constituent of Concern	Screen Out Advective Travel Time	Screen Out Decay Travel Time	Screen Out Initial Concentration	Screen Out ODAST Output	Found in GW	Constituent of Concern
Inorganics						
Antimony				X	X	X
Arsenic	X				X	X
Barium				X	X	X
Beryllium	X					
Boron						X
Cadmium				X		
Chromium	X					
Cobalt	X					
Copper				X		
Cyanide						X
Lead				X	X	X
Manganese				X	X	X
Mercury				X		
Molybdenum						X
Nickel	X					
Selenium	X					
Silver	X					
Thallium	X					
Tin	X					

12021

D-3-47

TABLE D.3-7
(Continued)

Potential Constituent of Concern	Screen Out Advective Travel Time	Screen Out Decay Travel Time	Screen Out Initial Concentration	Screen Out ODAST Output	Found in GW	Constituent of Concern
Vanadium	X					
Zinc	X					
Organics						
1,2,3,7,8-Pentachlorodibenzofuran	X					
2,3,4,7,8-Pentachlorodibenzofuran	X					
2,4,5-Trichlorophenol		X				
4,4-DDT	X					
4-Nitrophenol		X				
4-Nitroaniline				X		
Acenaphthene		X				
Anthracene		X				
Aroclor-1221						X
Aroclor-1248	X					
Aroclor-1254	X					
Aroclor-1260	X					
Benzo(a)anthracene	X					
Benzo(a)pyrene	X					
Benzo(b)fluoranthene	X					
Benzo(ghi)perylene	X					
Benzo(ghi)fluoranthene	X					

TABLE D.3-7
(Continued)

4287

Potential Constituent of Concern	Screen Out Advective Travel Time	Screen Out Decay Travel Time	Screen Out Initial Concentration	Screen Out ODAST Output	Found in GW	Constituent of Concern
Benzo(k)fluoranthene	X					
Chrysene	X					
Dibenzo(a,h)anthracene	X					
Dichlorodifluoromethane						X
Fluoranthene	X					
Fluorene		X				
Heptachlorodibenzofuran	X					
Heptachlorodibenzo-p-dioxin	X					
Hexachlorodibenzofuran	X					
Hexachlorodibenzo-p-dioxin	X					
Indeno(1,2,3-cd)pyrene	X					
Naphthalene		X				
Octachlorodibenzofuran	X					
Octachlorodibenzo-p-dioxin	X					
Pentachlorophenol	X					
Phenanthrene		X				
Pyrene	X					
Tetrachlorodibenzofuran	X					
Tetrachloroethene						X
Vinyl Chloride						X

D-3-49

0157

TABLE D.3-7
(Continued)

Potential Constituent of Concern	Screen Out Advective Travel Time	Screen Out Decay Travel Time	Screen Out Initial Concentration	Screen Out ODAST Output	Found in GW	Constituent of Concern
Radionuclides						
Cesium-137	X					
Neptunium-237						X
Plutonium-238	X				X	X
Plutonium-239/240	X					
Radium-226	X				X	X
Ruthenium-106		X				
Strontium-90					X	X
Technetium-99					X	X
Thorium-230	X				X	X
Thorium-232	X					
Uranium-234					X	X
Uranium-235					X	X
Uranium-238					X	X

D-3-50

0158

4282

TABLE D.3-8

INPUT PARAMETERS AND FORMULAS FOR TRAVEL TIME SCREENING

Parameter	Units	Waste Pit 1	Waste Pit 2	Waste Pit 3	Waste Pit 4	Waste Pit 5	Waste Pit 6	Burn Pit	Clearwell
Thickness Vadose 1	(ft)	2.00	13.00	0.00	13.00	13.30	15.90	12.90	0.00
Thickness Vadose 2	(ft)	24.30	20.00	23.70	21.70	23.00	24.30	21.70	23.70
Total Thickness L	(ft)	26.30	33.00	23.70	34.70	36.30	40.20	34.60	23.70
Infiltration Rate q	(in/yr)	3.281	6.023	9.828	10.708	16.091	23.466	2.818	10.051
Infiltration Rate q	(ft/day)	7.491×10^{-4}	1.375×10^{-3}	2.244×10^{-3}	2.445×10^{-3}	3.674×10^{-3}	5.358×10^{-3}	6.434×10^{-3}	2.295×10^{-3}
V Vadose 1	(ft/day)	2.531×10^{-3}	4.538×10^{-3}	7.265×10^{-3}	7.889×10^{-3}	1.167×10^{-2}	1.677×10^{-2}	2.187×10^{-3}	7.423×10^{-3}
V Vadose 2	(ft/day)	5.171×10^{-3}	8.987×10^{-3}	1.403×10^{-3}	1.517×10^{-3}	2.198×10^{-2}	3.098×10^{-2}	4.502×10^{-3}	1.432×10^{-2}
Nd Vadose 1		1.638×10^{-1}	1.690×10^{-2}		1.262×10^{-2}	1.061×10^{-2}	8.038×10^{-3}	2.84×10^{-2}	
Nd Vadose 2		8.368×10^{-3}	7.762×10^{-3}	5.636×10^{-3}	6.032×10^{-3}	5.277×10^{-3}	4.789×10^{-3}	1.017×10^{-2}	5.606×10^{-3}
Brenner Multiplier M Vadose 1		0.1	0.4		0.5	0.5	0.5	0.3	
Brenner Multiplier M Vadose 2		0.5	0.5	0.6	0.6	0.6	0.6	0.5	0.6

Formulas:

$$Nd = D/(V)(L)$$

$$D = 6.458 \times 10^{-4} + (0.14)(V)^{1.11}$$

D-3-51

0159

TABLE D.3-9

TOXICITY SCREENING FOR CONSTITUENTS THAT PASSED TRAVEL TIME SCREENING

Constituent	Leachate B Conecntrations						Burn Pit	Clearwell	Maximum Concentration	Screening Level	Screen Out
	Waste Pit 1	Waste Pit 2	Waste Pit 3	Waste Pit 4	Waste Pit 5	Waste Pit 6					
Radionuclides ^a											
Neptunium-237		3.00 x 10 ⁻⁶	1.1 x 10 ⁻¹⁰	1.45 x 10 ⁻⁹	5.00 x 10 ⁻⁷	1.06 x 10 ⁻⁵	1.50 x 10 ⁻⁹	4.51 x 10 ⁻⁴	4.51 x 10 ⁻⁴	3.40 x 10 ⁻⁴	No
Strontium-90	2.84 x 10 ⁻¹⁴	3.14 x 10 ⁻¹⁴	8.30 x 10 ⁻¹³	7.31 x 10 ⁻¹³	2.90 x 10 ⁻¹⁰	7.00 x 10 ⁻¹²	1.67 x 10 ⁻¹³	1.06 x 10 ⁻¹¹	2.90 x 10 ⁻¹⁰	1.10 x 10 ⁻¹²	No
Technetium-99	2.18 x 10 ⁻⁶	5.33 x 10 ⁻⁶	2.06 x 10 ⁻⁵	2.07 x 10 ⁻⁵	1.88 x 10 ⁻⁵	1.61 x 10 ⁻⁴	1.47 x 10 ⁻⁶	2.36 x 10 ⁻⁴	2.36 x 10 ⁻⁴	2.40 x 10 ⁻⁷	No
Uranium-234	5.75 x 10 ⁻⁴	1.74 x 10 ⁻⁴	2.57 x 10 ⁻⁴	2.38 x 10 ⁻²	6.79 x 10 ⁻³	1.38 x 10 ⁻³	1.46 x 10 ⁻⁴	3.07 x 10 ⁻⁴	2.38 x 10 ⁻²	5.3 x 10 ⁻⁴	No
Uranium-235	1.24 x 10 ⁻¹	3.68 x 10 ⁻²	3.67 x 10 ⁻²	12.7	8.9 x 10 ⁻³	4.62 x 10 ⁻³	3.04 x 10 ⁻²	5.6 x 10 ⁻²	12.58	1.5E x 10 ⁻⁴	No
Uranium-238	11.93	3.73	7.42	1.28 x 10 ³	1.2	1.5	2.95	18.6	18.6	5.6 x 10 ⁻⁴	No
Inorganics ^a											
Antimony	3.23 x 10 ⁻¹	5.71 x 10 ⁻¹	6.56 x 10 ⁻¹	9.56 x 10 ⁻¹	1.58 x 10 ⁻¹		1.03 x 10 ⁻¹	7.00 x 10 ⁻⁴	9.56 x 10 ⁻¹	1.5 x 10 ⁻³	No
Barium	1.92 x 10 ⁰	1.56 x 10 ⁻¹	2.61 x 10 ⁻²	4.41 x 10 ⁻²	6.28 x 10 ⁻¹	1.96 x 10 ⁰	3.50 x 10 ⁻²	1.35 x 10 ⁻²	1.96 x 10 ⁰	2.60 x 10 ⁻¹	No
Boron	1.23 x 10 ⁰	2.82 x 10 ⁰	5.48 x 10 ⁰	2.93 x 10 ⁰			2.12 x 10 ⁰		5.48 x 10 ⁰	3.30 x 10 ⁰	No
Cadmium	4.14 x 10 ⁻²	2.79 x 10 ⁻¹	3.11 x 10 ⁻¹	1.18 x 10 ⁻¹	9.40 x 10 ⁻³	9.50 x 10 ⁻⁴	1.97 x 10 ⁻²	9.50 x 10 ⁻⁴	3.11 x 10 ⁻¹	1.80 x 10 ⁻³	No
Copper	8.32 x 10 ⁻²	1.45 x 10 ⁻¹	7.82 x 10 ⁻¹	6.43 x 10 ⁻¹	9.48 x 10 ⁻¹	6.00 x 10 ⁻³	1.18 x 10 ⁻¹	1.90 x 10 ⁻²	9.48 x 10 ⁻¹	1.4 x 10 ⁻¹	No
Cyanide	5.44 x 10 ⁻¹	3.16 x 10 ⁻²	1.27 x 10 ⁰	2.65 x 10 ⁻²	8.64 x 10 ⁻²	2.90 x 10 ⁻²	3.60 x 10 ⁰	8.70 x 10 ⁻²	3.60 x 10 ⁰	1.80 x 10 ⁻²	No
Lead	4.80 x 10 ⁻³	1.83 x 10 ⁻²	1.61 x 10 ⁰	2.00 x 10 ⁻³	1.77 x 10 ⁻²	6.91 x 10 ⁻¹	1.13 x 10 ⁻²	5.50 x 10 ⁻⁴	1.61 x 10 ⁰	1.50 x 10 ⁻³	No
Manganese	7.71 x 10 ⁻²	3.93 x 10 ⁻³	1.97 x 10 ⁻¹	5.98 x 10 ⁻³	2.41 x 10 ⁰	2.01 x 10 ⁰	2.98 x 10 ⁻²	2.00 x 10 ⁻²	2.41 x 10 ⁰	1.80 x 10 ⁻²	No
Mercury	1.80 x 10 ⁻¹⁰	9.80 x 10 ⁻¹¹	2.16 x 10 ⁻¹¹	8.80 x 10 ⁻⁹	2.18 x 10 ⁻²	5.00 x 10 ⁻³	2.40 x 10 ⁻⁴	1.00 x 10 ⁻⁴	2.18 x 10 ⁻²	1.10 x 10 ⁻³	No
Molybdenum	3.61 x 10 ⁻¹	1.57 x 10 ⁰	1.57 x 10 ⁰	6.29 x 10 ⁻¹	1.50 x 10 ⁰		1.05 x 10 ⁰	5.28 x 10 ⁰	1.50 x 10 ⁰	1.80 x 10 ⁻²	No
Organics ^b											
4-nitroaniline		5.00 x 10 ¹							5.00 x 10 ¹	1.10 x 10 ¹	No
Aroclor-1221	2.50 x 10 ⁰								2.50 x 10 ⁰	1.00 x 10 ⁻³	No
Dichlorofluoromethane	2.00 x 10 ²								2.00 x 10 ²	3.90 x 10 ¹	No
Tetrachloroethene	4.70 x 10 ¹			1.40 x 10 ²		6.00 x 10 ⁰	2.00 x 10 ⁰		1.40 x 10 ²	1.30 x 10 ⁻¹	No

^aInitial concentration in parts per million (ppm).^bInitial concentration in parts per billion (ppb).

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TABLE D.3-10
CONSTITUENTS DETECTED IN WELLS 2019, 2021, 2027, AND 2648

Constituent	Constituent	Constituent
1,1-Dichloroethane	Magnesium, (Dissd.)	TH-230
Alkalinity at CaCO ₃	Manganese	TOC
Aluminum	Manganese, (Dissd.)	Total dissolved solids
Antimony	Molybdenum	U-234
Ammonia, as nitrogen	NP-237	U-235/236
Arsenic	Nickel	U-238
Barium	Nickel, (Dissd.) Nitrogen, Nitrate	U-TOTAL
Barium, (Dissd.)	Nitrogen, Nitrate+Nitrite	Vanadium
Calcium	PU-238	Zinc
Calcium, (Dissd.)	pH	Zinc, (Dissd.)
Chloride	Phosphorus, Total Potassium	
Chromium, Total	Potassium, (Dissd.)	
Copper	RA-226	
Copper, (Dissd.)	RA-228	
Fluoride	Selenium	
GROSS ALPHA	Sodium	
GROSS BETA	Sodium, (Dissd.)	
Iron	Specific conductance	
Iron, (Dissd.)	Sulfate	
Lead	TC-99	
Magnesium	TH-228	

TABLE D.3-11
BACKGROUND SCREENING FOR CONSTITUENTS FOUND IN THE GREAT MIAMI AQUIFER
AND POTENTIAL TRAVEL TO FENCELINE

Constituent	Maximum Concentration (mg/l or pCi/l)	Background Concentration (mg/l or pCi/l)	Background Concentration Basis ^a	Above Background?	Retardation Factor (R)	Reach Fenceline? (Rcrit > R) ^b	Groundwater Model Calibration Required?
Inorganics	mg/l	mg/l					
Antimony	0.175	0.006	MCL	Yes	1230	No	No
Arsenic	0.582	0.05	MCL	Yes	278	No	No
Barium	0.651	0.18	UCL	Yes	124	Yes	Yes
Chromium	0.066	0.1	MCL	No			No
Copper	0.176	0.27	UTL	No			No
Lead	0.058	0.015	MCL	Yes	235	No	No
Manganese	2.072	0.736	UCL	Yes	309	No	No
Molybdenum	0.031	0.04	UTL	No			No
Nickel	0.064	0.1	MCL	No			No
Selenium	0.005	0.006	UTL	No			No
Silver	0.0015	0.1	MCL	No			No
Zinc	0.319	0.735	UCL	No			No
Radionuclides	pCi/l	pCi/l					
Plutonium-238	0.133	1.0	UTL ^c	No	616	No	No
Radium-226	1.78	8.5	UTL ^c	No	653	No	No
Strontium-90	0.731	5	UTL ^c	No	16.4	Yes	Yes
Technetium-99	6860	36	UTL ^c	Yes	1.43	Yes	Yes

4282

TABLE D.3-11
(Continued)

Constituent	Maximum Concentration (mg/l or pCi/l)	Background Concentration (mg/l or pCi/l)	Background Concentration Basis ^a	Above Background?	Retardation Factor (R)	Reach Fenceline? (Rcrit > R) ^b	Groundwater Model Calibration Required?
Radionuclides	pCi/l	pCi/l					
Thorium-230	1.04	3.44	UTL ^c	No	19,700	No	No
Uranium-234	7.99	4.2	UTL ^c	Yes	10.1	Yes	Yes
Uranium-235	0.5955	1.0	UTL ^c	No	10.1	Yes	Yes
Uranium-238	6.34	4.4	UTL ^c	Yes	10.1	Yes	Yes

^a MCL - Maximum Contaminant Level; UTL - Upper Tolerance Level based on background sampling; UCL - Upper Confidence Limit based on background sampling.

^b Rcrit = 155

^c Background concentrations for radionuclides from Table 9 of the *Characterization of Background Water Quality for Streams and Groundwater* (Draft) (DOE May 1993c). Due to the draft nature of the values, they are not used to screen out constituents. UTL was set equal to the maximum detected value or maximum sample quantitation limit, whichever is larger.

D-3-55

0163

TABLE D.3-12

CONSTITUENTS OF CONCERN SUMMARY LIST

Potential Constituent of Concern	Loading Case ^a	Passed Natural Migration Screening ^b	Found in Groundwater Above Background Concentration ^b	Reaches Fenceline ^c	Reported Maximum Aquifer Concentration ^{c,d}	Requires SWIFT Modeling	Requires SWIFT Model Calibration
Radionuclides							
Neptunium-237	Case 2	X				X	
Plutonium-238	Case 3		X	No	0.133 pCi/l		
Radium-226	Case 3		X	No	1.78 pCi/l		
Strontium-90	Case 1	X	X	Yes	0.731 pCi/l	X	X
Technetium-99	Case 4	X	X	Yes	6,860 pCi/l	X	X
Thorium-230	Case 3		X	No	1.04 pCi/l		
Uranium-234	Case 1	X	X	Yes	7.99 pCi/l	X	X
Uranium-235	Case 1	X	X	Yes	0.5955 pCi/l	X	X
Uranium-238	Case 1	X	X	Yes	6.34 pCi/l	X	X
Inorganics							
Antimony	Case 2		X	No	0.175mg/l		
Arsenic	Case 3		X	No	0.582mg/l		
Barium	Case 2		X	Yes	0.651mg/l	X	X
Boron	Case 1	X				X	
Cyanide	Case 2	X				X	
Lead	Case 2		X	No	0.058 mg/l		
Manganese	Case 2		X	No	2.072 mg/l		

4282

D-3-56

0164

TABLE D.3-12
(Continued)

Potential Constituent of Concern	Loading Case ^a	Passed Natural Migration Screening ^b	Found in Groundwater Above Background Concentration ^b	Reaches Fenceline ^c	Reported Maximum Aquifer Concentration ^{c,d}	Requires SWIFT Modeling	Requires SWIFT Model Calibration
Molybdenum	Case 1	X				X	
Organics							
Aroclor-1221	Case 2	X				X	
Dichlorodifluoromethane	Case 4	X				X	
Tetrachloroethene	Case 4	X				X	
Vinyl Chloride	Case 4	X				X	

^a See Figure D.3-3 for loading case designation.

^b See Figure D.3-13 for overall screening approach.

^c See Figure D.3-2 for screening approach.

^d If reported maximum aquifer concentration doesn't reach fenceline, then it represents the maximum on-site concentration used in the baseline risk assessment.

TABLE D3-13
PROJECTED MAXIMUM PERCHED WATER CONCENTRATIONS 4787

Leachate B or Organic Leachate Concentration					
Constituent	Pit 4	Pit 5	Pit 6	Burn Pit	Maximum
Inorganics (ppm)					
Antimony	0.956	0.1577	NA	0.103	0.956
Arsenic	0.0025	0.00928	0.6316	0.0494	0.6316
Barium	0.041	0.628	1.9559	0.035	1.9559
Beryllium	7.12×10^{-4}	0.0198	0.0204	8.22×10^{-4}	0.0204
Boron	2.93	NA	NA	2.12	2.93
Cadmium	0.118	0.0094	9.5×10^{-4}	0.0197	0.118
Chromium	0.0406	0.0243	2.2×10^{-3}	0.129	0.129
Cobalt	0.338	0.0748	4.75×10^{-3}	0.0377	0.338
Copper	0.643	0.9478	0.006	0.118	0.9478
Cyanide	0.0265	8.64×10^{-2}	NA	3.6	3.6
Lead	0.002	0.0177	0.6914	0.0113	0.6914
Manganese	5.98×10^{-3}	2.4135	2.008	0.0298	
Mercury	8.8×10^{-9}	0.0218	NA	2.4×10^{-8}	0.0218
Molybdenum	0.629	1.15×10^2	NA	1.05	1.15×10^2
Nickel	2.13	0.3025	0.165	0.299	2.13
Selenium	0.0025	0.0021	NA	0.0038	0.0038
Silver	0.0041	3.35×10^{-3}	0.0667	2.06×10^{-3}	0.0667
Thallium	0.01	5.5×10^{-4}	0.7535	0.0002	0.7535
Tin	0.2	8.29	1.3	NA	8.29
Vanadium	0.929	1.4388	0.007	0.0743	1.4388
Zinc	0.0145	0.3338	1.7918	0.011	1.7918
Radionuclides (ppm)					
Cesium-137	NA	1.04×10^{-9}	8.6×10^{-11}	NA	1.04×10^{-9}
Neptunium-237	1.45×10^{-9}	5.0×10^{-7}	1.06×10^{-5}	2.1×10^{-9}	1.06×10^{-5}
Plutonium-238	2.86×10^{-11}	2.8×10^{-12}	1.1×10^{-11}	2.86×10^{-11}	2.86×10^{-11}
Plutonium-239/240	1.01×10^{-10}	8×10^{-10}	8×10^{-10}	9.1×10^{-11}	8×10^{-10}
Radium-226	9.4×10^{-9}	NA	5.0×10^{-11}	7.33×10^{-8}	7.33×10^{-8}

TABLE D.3-13
(Continued)

Leachate B or Organic Leachate Concentration					
Constituent	Pit 4	Pit 5	Pit 6	Burn Pit	Maximum
Ruthenium-106	NA	1.27×10^{-11}	NA	NA	1.27×10^{-11}
Strontium-90	7.31×10^{-13}	2.9×10^{-10}	7.0×10^{-12}	1.77×10^{-11}	2.9×10^{-10}
Technetium-99	2.07×10^{-5}	1.88×10^{-5}	1.612×10^{-4}	1.47×10^{-6}	1.612×10^{-4}
Thorium-230	2.1×10^{-9}	5.14×10^{-9}	1.5×10^{-8}	NA	1.5×10^{-8}
Thorium-232	2.1×10^{-9}	4.6×10^{-4}	4.6×10^{-4}	NA	4.6×10^{-4}
Thorium - Total	2.1×10^{-9}	NA	NA	2.12×10^{-9}	2.12×10^{-9}
Uranium-234	0.0238	6.79×10^{-5}	1.377×10^{-5}	1.45×10^{-4}	0.0238
Uranium-235	12.78	0.0089	4.62×10^{-3}	0.0301	12.78
Uranium-238	1,280	1.2	1.496	2.95	1,280
Uranium-Total	500	NA	NA	2.87	500
Organics (ppb)					
1,2,3,7,8-Pentachlorodibenzofuran	1×10^{-3}	NA	NA	NA	1×10^{-3}
2,3,4,7,8-Pentachlorodibenzofuran	1.1×10^{-3}	NA	NA	NA	1×10^{-3}
2,4,5-Trichlorophenol	NA	NA	NA	NA	NA
4,4-DDT	NA	NA	NA	NA	NA
4-Nitroaniline	NA	NA	NA	NA	NA
4-Nitrophenol	10	NA	NA	NA	10
Ancenaphthene	12	NA	NA	40	40
Anthracene	17	NA	NA	40	40
Aroclor-1221	NA	NA	NA	NA	NA
Aroclor-1248	50	0.5	NA	NA	50
Aroclor-1254	100	1	0.5	10	100
Aroclor-1260	NA	NA	NA	NA	NA
Benzo(a)anthracene	10	NA	NA	40	40
Benzo(a)pyrene	10	NA	NA	40	40
Benzo(b)fluoranthene	10	NA	NA	40	40
Benzo(ghi)perylene	10	NA	NA	40	40

TABLE D-3-13
(Continued)

4787

Leachate B or Organic Leachate Concentration					
Constituent	Pit 4	Pit 5	Pit 6	Burn Pit	Maximum
Benzo(ghi)fluoranthene	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	10	NA	NA	40	40
Chrysene	10	NA	NA	40	40
Dibenzo(a,h)anthracene	10	NA	NA	NA	10
Dichlorodifluoromethane	NA	NA	NA	NA	NA
Fluoranthene	2	NA	NA	40	40
Fluorene	9	NA	NA	40	40
Heptachlorodibenzofuran	2.4×10^{-3}	NA	NA	NA	2×10^{-3}
Heptachlorodibenzo-p-dioxin	9.4×10^{-4}	NA	NA	7.2×10^{-4}	9.4×10^{-4}
Hexachlorodibenzofuran	1.2×10^{-3}	NA	NA	NA	1.2×10^{-3}
Hexachlorodibenzo-p-dioxin	7.5×10^{-4}	NA	NA	NA	7.5×10^{-4}
Indeno(1,2,3-cd)pyrene	10	NA	NA	40	40
Naphthalene	16	NA	NA	12	16
Octachlorodibenzofuran	9×10^{-4}	NA	NA	1.1×10^{-3}	1.1×10^{-3}
Octachlorodibenzo-p-dioxin	1.2×10^{-3}	NA	NA	1.8×10^{-3}	1.8×10^{-3}
Pentachlorophenol	NA	NA	NA	200	200
Phenanthrene	10	NA	NA	40	40
Pyrene	10	NA	NA	40	40
Tetrachlorodibenzofuran	5.3×10^{-3}	NA	NA	NA	5.3×10^{-3}
Tetrachloroethene	140	NA	6	2	140
Vinyl Chloride	6	NA	NA	1,000	1,000

NP = Not Present

NA = Not detected in pit materials or analysis results not available

TABLE D.3-14

SUMMARY OF LOADING TIMES AND CONCENTRATIONS FOR
CONSTITUENTS OF CONCERN

Constituents of Concern	Minimum Time of Arrival to the Aquifer (years) ^a	Time of Maximum Loading Concentration (years)	Maximum Loading Rates to the Aquifer (mg/day)	Maximum Loading Concentration (mg/l)
Vadose Zone Pathway Waste Area Source				
Radionuclides				
Np-237	440	980-1,000	1.135×10^{-2}	1.231×10^{-5}
Sr-90	100	180-200	8.2×10^{-8}	8.971×10^{-11}
Tc-99	5	10-15	3.786×10^{-1}	4.110×10^{-4}
U-234	10	620-630	5.8684×10^2	1.381×10^{-2}
U-235	10	620-630	3.88549×10^2	9.205×10^2
U-238	10	620-630	5.18150×10^5	1.228×10^3
Inorganics				
Boron	90	350-360	3.1×10^3	7.330×10^0
Cyanide	5	10-15	7.94×10^0	1.870×10^{-2}
Molybdenum	620	980-1,000	3.60×10^{-1}	2.710×10^{-3}
Organics				
Aroclor-1221	680	980-1,000	1.26×10^0	9.821×10^{-3}
Dichlorodifluorouethane	15	35-40	2.20×10^{-1}	1.731×10^{-3}
Tetrachloroethene	40	80-85	9.81×10^{-4}	1.051×10^{-6}
Vinyl Chloride	5	20-25	2.442×10^1	1.03×10^{-2}
Perched Groundwater Source				
Radionuclides				
Tc-99	10	20-30	24×10^{-4}	5.67×10^{-6}
U-234	400	530-540	1.65×10^{-4}	3.91×10^{-7}
U-235	400	530-540	0.11	2.59×10^{-4}
U-238	400	530-540	14.62	3.45×10^{-2}
Inorganics				
Arsenic	>1,000			

^aModel simulation time = 0 is 1953 for the waste area source and time = 0 is 1993 for perched groundwater source.

TABLE D.3-15
SOURCE AREAS FOR OPERABLE UNIT 1 AQUIFER MODEL

4782

Location	Area		Number of Cells for Modeled Area
	(m ²)	(ft ²)	
Pit 1	7,682	82,691	5
Pit 2	4,172	44,901	3
Pit 3	22,422	241,347	15
Pit 4	7,785	83,799	5
Pit 5	14,965	161,077	10
Pit 6	3,011	32,410	2
Burn Pit	2,019	21,732	1
Clearwell	2,737	29,461	2

TABLE D-3-16

DISTRIBUTION COEFFICIENTS AND DECAY FACTORS FOR COMPOUNDS
MODELED BY SWIFT

Parameters	Distribution Coefficient (Kd) (ml/g)	Decay Factors (λ) (1/day)
Radionuclides		
Np-237	5.00	8.874×10^{-10}
Sr-90	2.50	6.640×10^{-5}
Tc-99	0.07	8.916×10^{-9}
U-234	1.48	7.767×10^{-9}
U-235	1.48	2.698×10^{-12}
U-238	1.48	4.250×10^{-13}
Inorganics		
Arsenic	45	NA
Barium	20	NA
Boron	3	NA
Cyanide	0.019	NA
Lead	38	NA
Molybdenum	10	NA
Organics		
Aroclor-1221	12.7	NA
Dichlorodifluoromethane	0.15	9.50×10^{-4}
Tetrachloroethene	0.35	4.20×10^{-4}
Vinyl Chloride	0.0041	2.40×10^{-4}

TABLE D.3-17

788

**SUMMARY OF CONSTITUENTS OF CONCERN
PREDICTED MAXIMUM CONCENTRATIONS IN GROUNDWATER**

Constituents of Concern	Time (yrs) ^b	Maximum Concentration in the Aquifer ^a
SWIFT Modeled Constituents		
Waste Area Source		
Radionuclides		
Np-237	1000	1.634×10^{-5}
Sr-90	200	1.368×10^{-12}
Tc-99	20	1.935×10^{-4}
U-234	630	1.414×10^{-4}
U-235	630	9.460×10^{-2}
U-238	630	1.2475×10^1
Inorganics		
Barium	1000	8.975×10^{-1}
Boron	360	7.894×10^{-2}
Cyanide	15	3.762×10^{-4}
Molybdenum	1000	4.93×10^{-5}
Organics		
Aroclor-1221	1000	2.690×10^{-5}
Dichlorodifluoromethane	40	5.400×10^{-6}
Tetrachloroethene	80	6.276×10^{-9}
Vinyl Chloride	25	1.459×10^{-3}
Perched Groundwater Source		
Radionuclides		
Tc-99	20	9.35×10^{-8}
U-234	540	1.71×10^{-7}
U-235	540	1.148×10^{-4}
U-238	540	1.514×10^{-2}
Inorganics		
Arsenic	>1,000	

4787

TABLE D.3-17
(Continued)

Constituents of Concern	Time (yrs) ^b	Maximum Concentration in the Aquifer ^a
Non-Modeled Constituents		
Waste Area Source		
Radionuclides		
Pu-238	40	0.133 pCi/l
Ra-226	40	1.78 pCi/l
Th-230	40	1.04 pCi/l
Inorganics		
Antimony	40	0.175
Arsenic	40	0.582
Lead	40	0.058
Manganese	40	2.072

^a All concentrations in milligrams per liter (ppm)^b Model simulation time = 0 is 1953 for waste area source and time = 0 is 1993 for perched groundwater source.

0173

TABLE D.3-18

4787

MAXIMUM CONCENTRATIONS OF COCs IN GROUNDWATER

Constituents of Concern	Concentration (mg/l)
Waste Area Source at 630 Years^{a,b}	
Radionuclides	
Np-237 ^a	1.65×10^{-10}
Sr-90 ^a	3.342×10^{-14}
Tc-99 ^a	9.856×10^{-7}
U-234	1.413×10^{-4}
U-235	9.464×10^{-2}
U-238	1.2475×10^1
Inorganics	
Barium	7.451×10^{-1}
Boron	3.077×10^{-2}
Cyanide	4.219×10^{-6}
Molybdenum	0.00
Organics	
Aroclor-1221	0.00
Dichlorodifluoromethane	7.375×10^{-12}
Tetrachloroethene	6.305×10^{-10}
Vinyl Chloride	0.00
Perched Groundwater Source at 540 Years^{d,e}	
Radionuclides	
Tc-99	4.98×10^{-11}
U-234	1.71×10^{-7}
U-235	1.148×10^{-4}
U-238	1.514×10^{-2}
Inorganics	
Arsenic	0.00

^aMaximum on-site risk within OU1 occurs at coordinates N 481,883, E 1,379,047.

^bModel simulation time = 0 is 1953.

^cNon-modeled constituents on Table D.3-17 are also assumed to be present at 630 years.

^dMaximum on-site risk within OU1 occurs at coordinates N 481,976, E 1,378,706.

^eModel simulation time = 0 is 1993.

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TABLE D.3-19

MAXIMUM CONCENTRATIONS OF COCs AT THE FENCELINE

Constituents of Concern	Concentration (mg/l)
Waste Area Source at 680 Years^{a,b}	
Radionuclides	
Np-237	1.957×10^{-17}
Sr-90	4.014×10^{-17}
Tc-99	1.865×10^{-7}
U-234	9.979×10^{-6}
U-235	6.689×10^{-3}
U-238	8.808×10^{-1}
Inorganics	
Barium	2.633×10^{-6}
Boron	6.766×10^{-3}
Cyanide	1.243×10^{-8}
Molybdenum	0.00
Organics	
Aroclor-1221	0.00
Dichlorodifluoromethane	1.104×10^{-14}
Tetrachloroethene	0.00
Vinyl Chloride	0.00
Perched Groundwater Source at 690 Years^{c,d}	
Radionuclides	
U-234	1.60×10^{-8}
U-235	1.098×10^{-5}
U-238	1.448×10^{-3}
Tc-99	3.81×10^{-21}
Inorganics	
Arsenic	0.00

^aMaximum off-site risk occurs at coordinates N 480,244, E 1,383,458.

^bModel simulation time = 0 is 1953.

^cMaximum off-site risk occurs at coordinates N 480,524, E 1,383,441.

^dModel simulation time = 0 is 1993.

TABLE D.3-20

**SUMMARY OF CONSTITUENTS OF CONCERN
PREDICTED MAXIMUM CONCENTRATIONS IN GROUNDWATER
SURFACE WATER PATHWAY**

4787

Constituents of Concern	Time (yrs) ^a	Maximum Concentration in the Aquifer ^b
Radionuclides^c		
U-234	10	3.0137×10^{-9}
U-238	10	2.660×10^{-4}
Inorganics		
Arsenic	210	7.196×10^{-8}

^aModel simulation time = 0 is 1993.

^bAll concentrations in milligrams per liter (ppm).

^cMaximum risk occurs at coordinates N 481,311, E 1,377,790

4787

TABLE D.3-21

**EFFECT OF CHANGES IN HYDRAULIC CONDUCTIVITY OF THE TILL LAYER
ON SEEPAGE RATE**

Run No.	Hydraulic Conductivity of Till (cm/sec)	Seepage Velocity (in/yr)
1	9.3×10^{-5} (Nominal)	10.92
2	9.3×10^{-6}	10.92
3	9.3×10^{-7}	10.37
4	9.3×10^{-8}	2.19
5	9.3×10^{-9}	0.22

0177

TABLE D.3-22

EFFECT OF VARYING HYDRAULIC CONDUCTIVITIES ON SEEPAGE VELOCITY

4787

Run No.	Hydraulic Conductivity of Layers	Seepage Velocity (in/yr)
1	Nominal values	3.28
2	10 x Nominal values	11.01
3	Nominal values/10	0.331

TABLE D.3-23

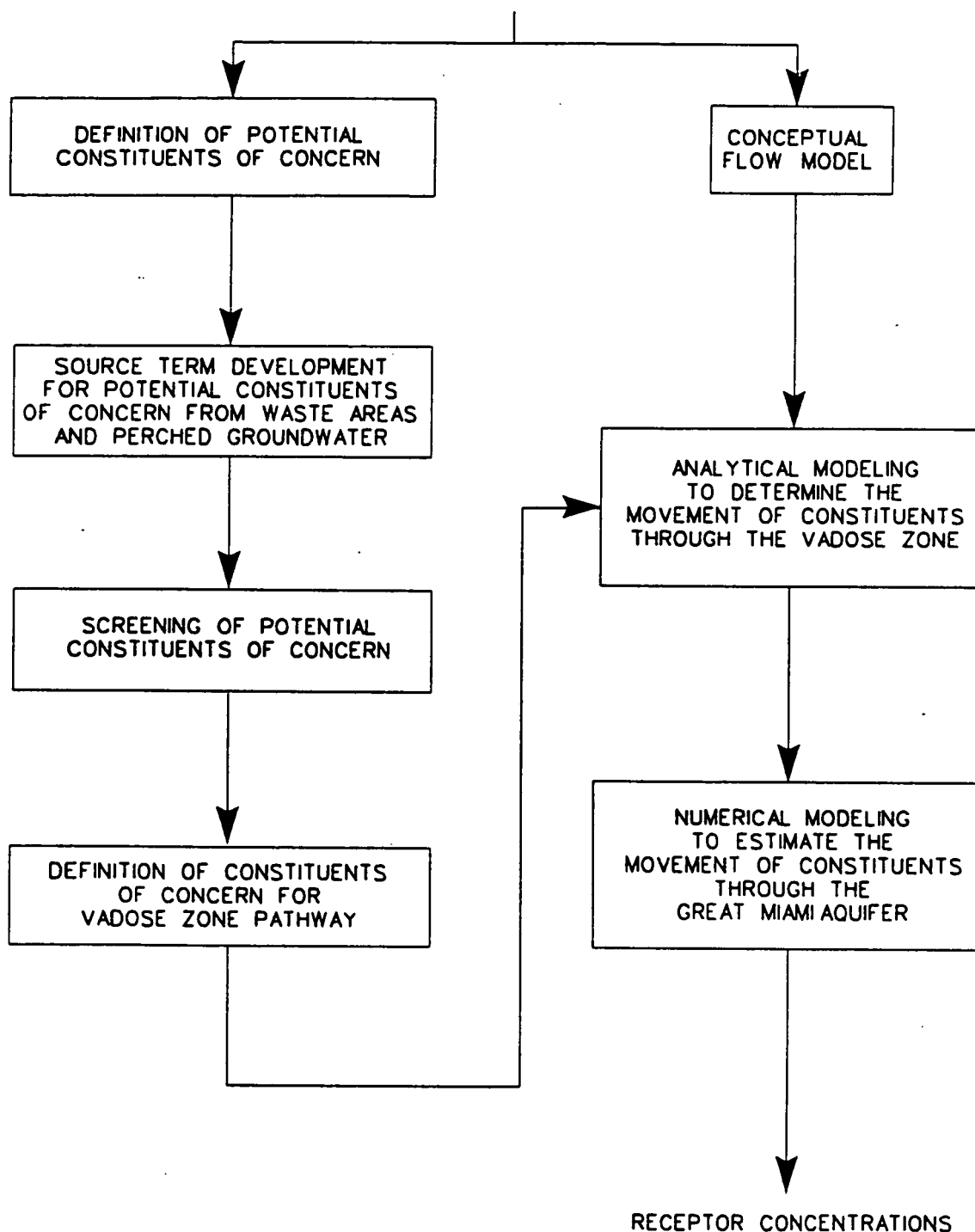
**SWIFT CONTAMINANT TRANSPORT SENSITIVITY RUNS
USING WASTE PIT 1 SOURCE**

Input or Result	Run No. 1	Run No. 2
K_d , ml/g	1.4	32
K_H , ft/day	700	200
K_V , ft/day	70	20
α_L , ft	200	50
α_T , ft	20	5
Maximum Conc.,ppb	57.6	555
Time of occurrence of maximum, year	620	1000 ^a
Approximate area of 1 ppb contour, acre	1500	25

^aThe run was terminated at 1,000 years at which time the concentrations were still increasing. Consequently, the actual time of occurrence of the maximum would be after 1,000 years.

0179

OPERABLE UNIT 1
WASTE AREA - VADOSE ZONE TO GROUNDWATER PATHWAY



SKX02069-A OU1 FAIR
SKX02069.DGN 08/11/93 BM

FIGURE D.3-1. VADOSE ZONE PATHWAY TRANSPORT MODELING DIAGRAM

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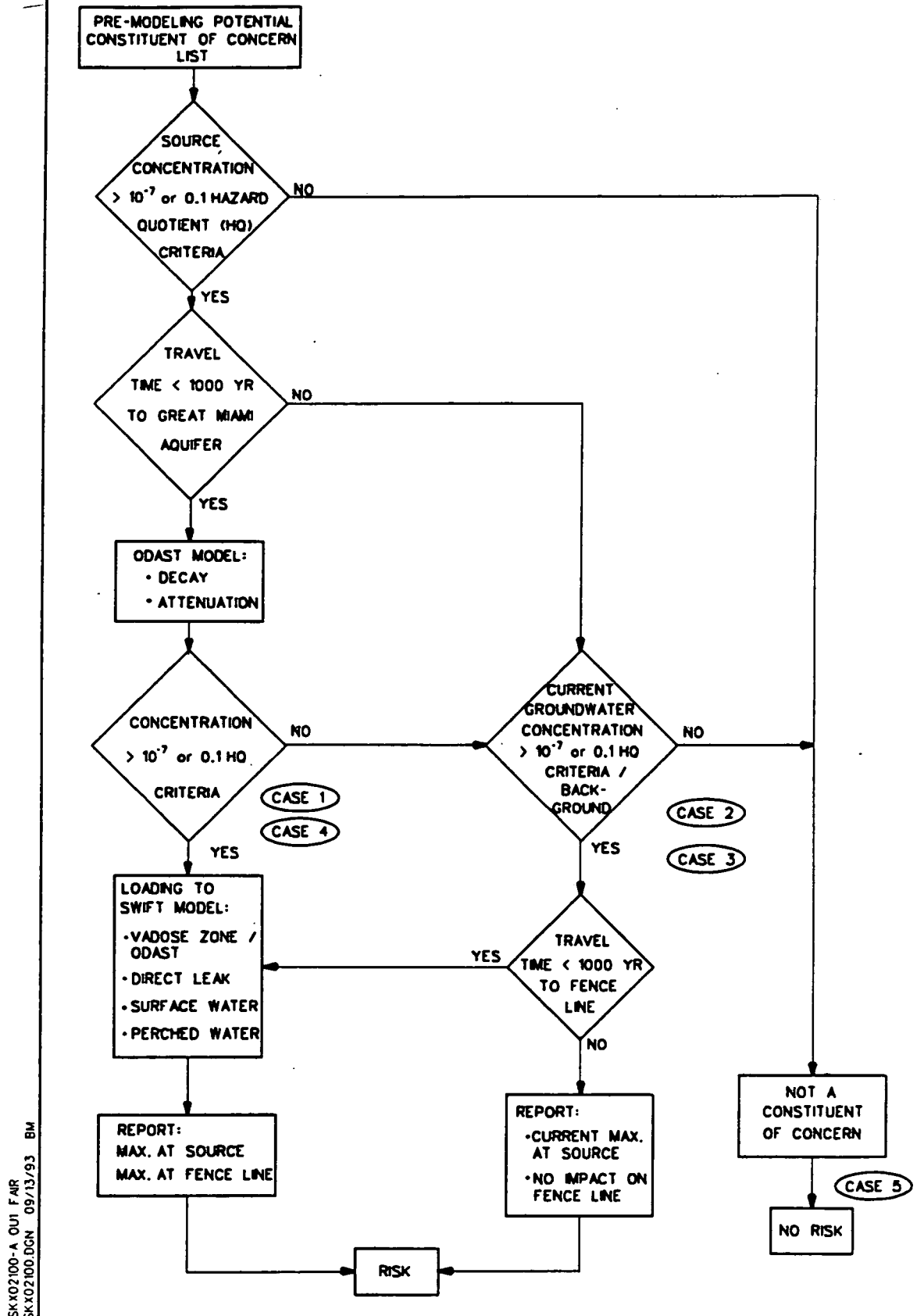


FIGURE D.3-2. APPROACH FOR SCREENING AND INCORPORATION
OF MONITORING DATA INTO THE MODELING PROCESS

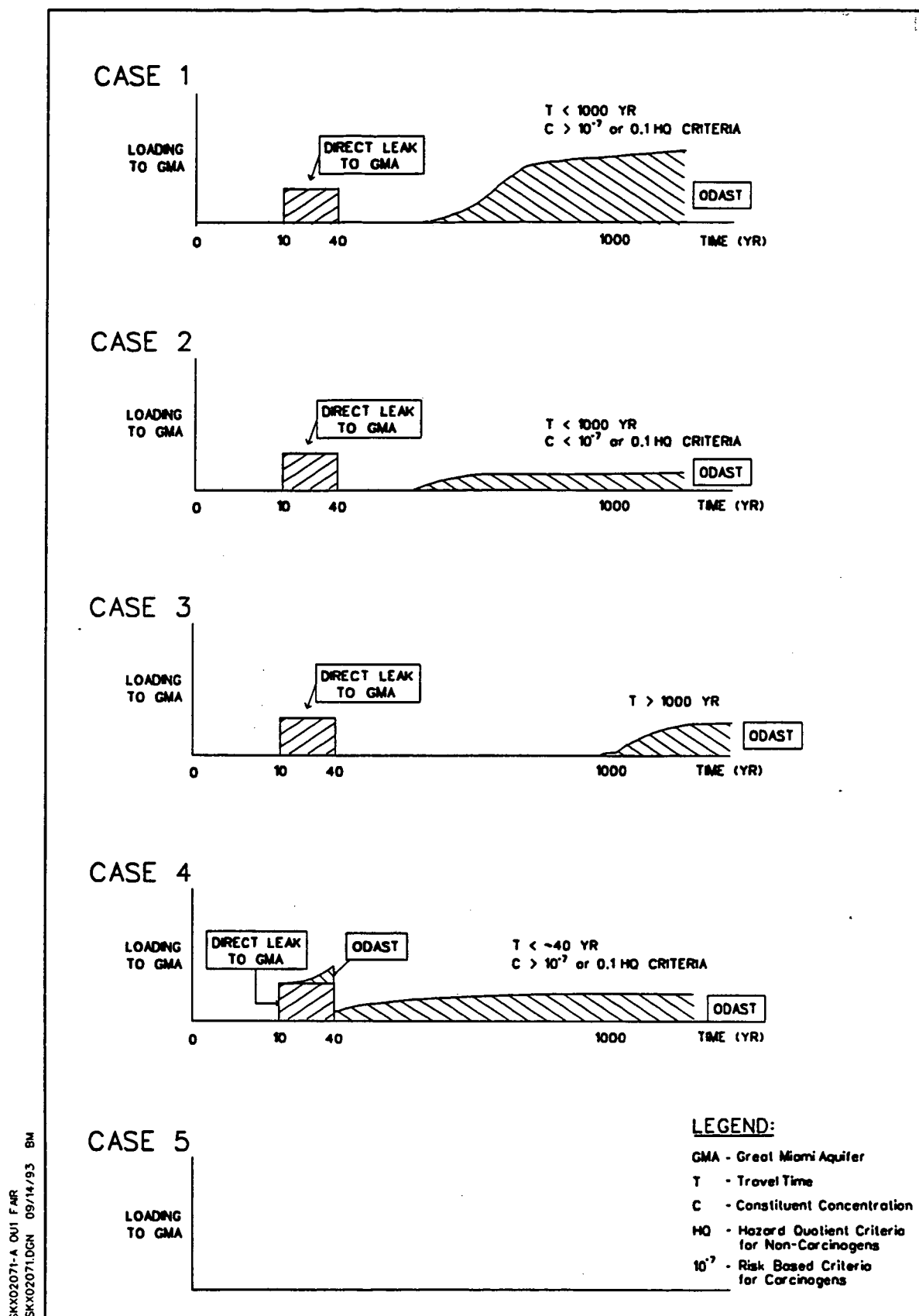
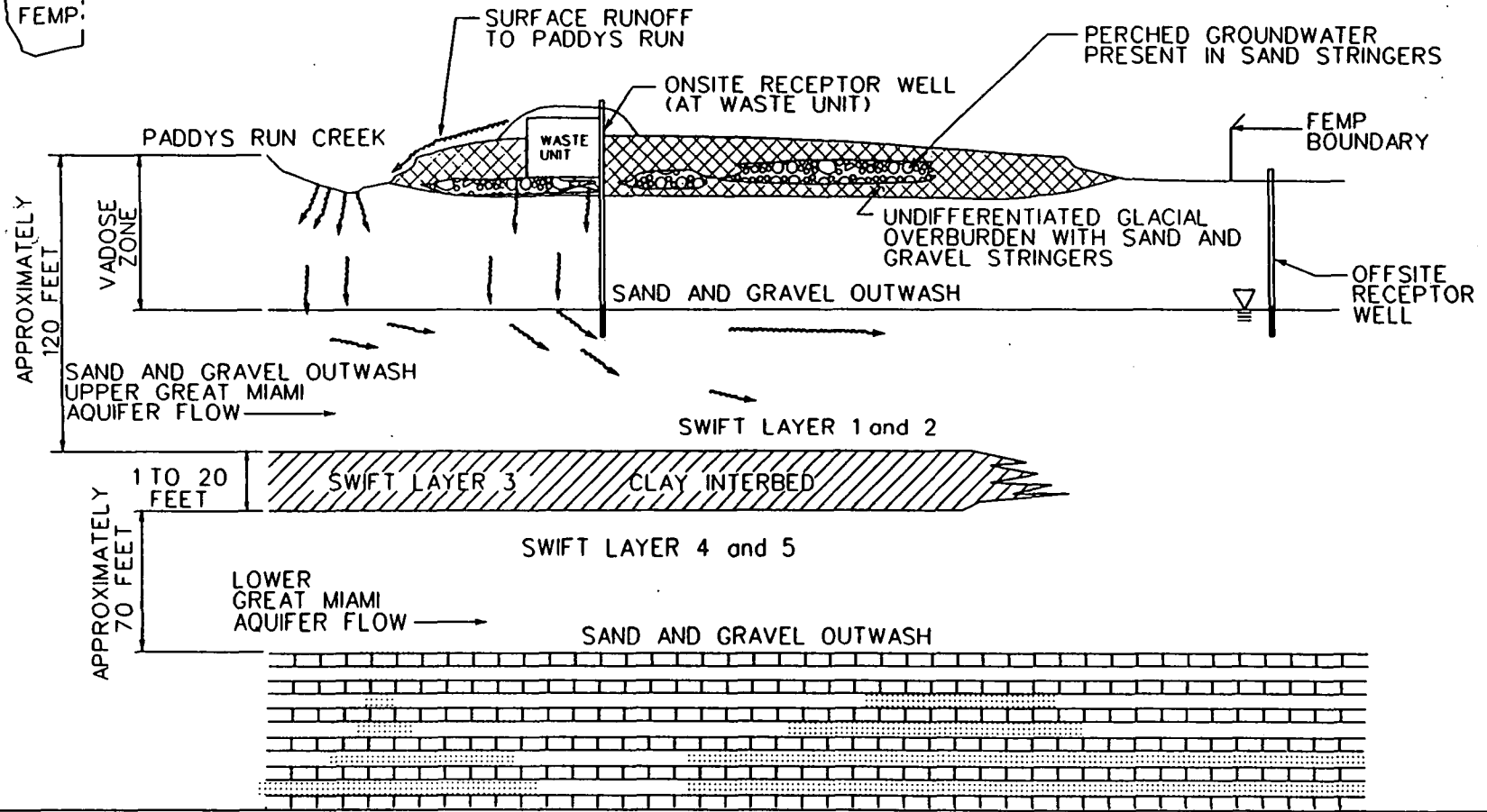
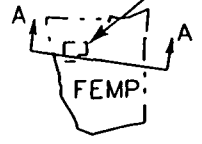


FIGURE D.3-3. CASES FOR LOADING CONSTITUENTS
TO THE GREAT MIAMI AQUIFER 0182

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OPERABLE UNIT 1



NOTES:

1. SOURCE RI/FS REPORT, 2-93, FIGURE 5-6.

LEGEND:

- SHALE WITH INTERBEDDED LIMESTONE SAND
- GLACIAL OVERBURDEN
- CLAY
- SAND & GRAVEL

FIGURE D.3-4. CONCEPTUAL MODEL OF CONTAMINANT TRANSPORT BY GROUNDWATER AT THE FEMP

D-3-75

0183

SKX02072-A OUT FMP
SKX02072 02/08/93 RW

SKX02064-A/OU1/FAIR
SKX02064.DGN/08/06/93/RM

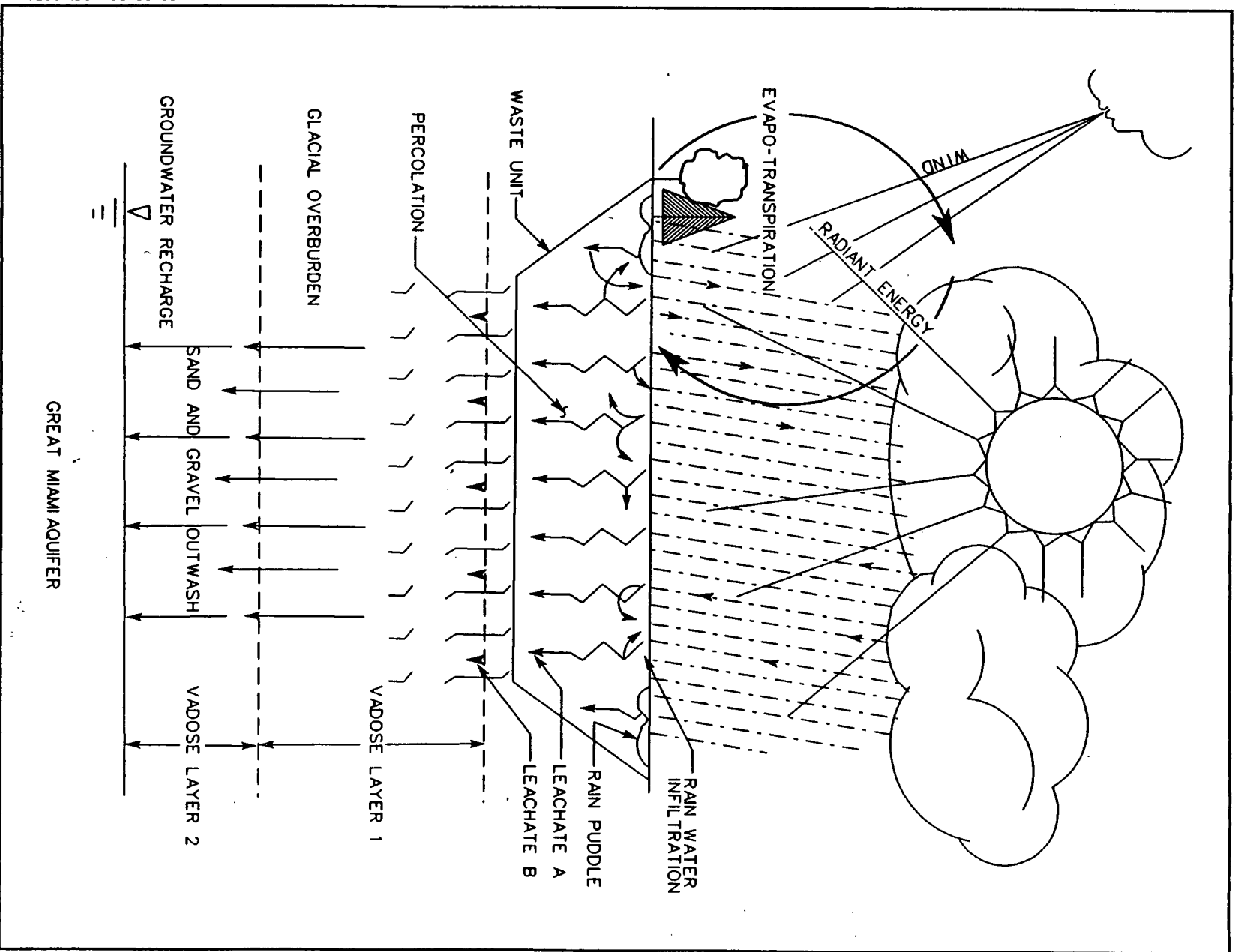


FIGURE D.3-5. CONCEPTUAL VADOSE ZONE MODEL

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D-3-77

4282

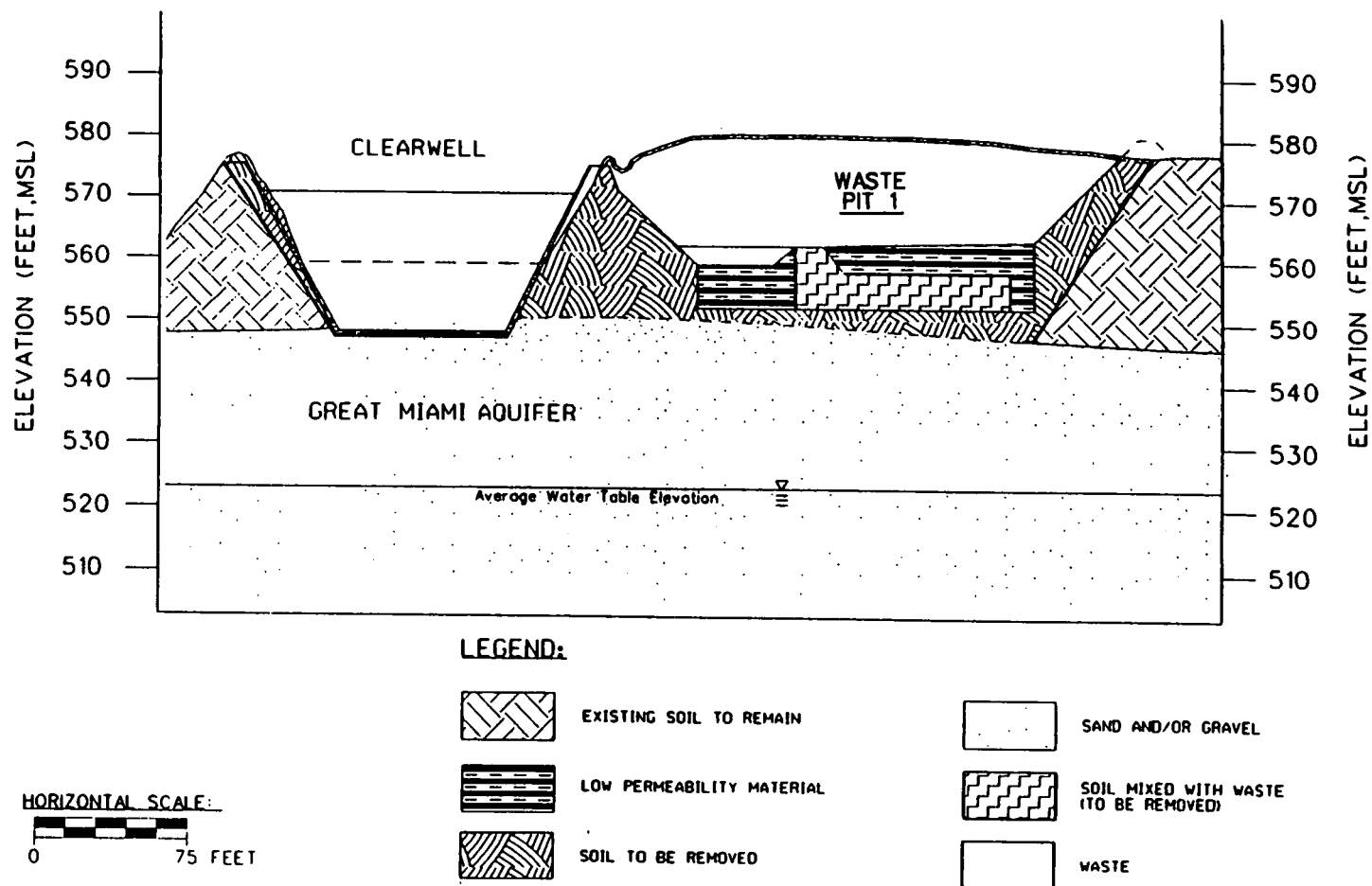


FIGURE D.3-6. CONCEPTUAL DIAGRAM OF OPERABLE UNIT 1 - PIT 1 AND THE CLEARWELL

D-3-79

0187

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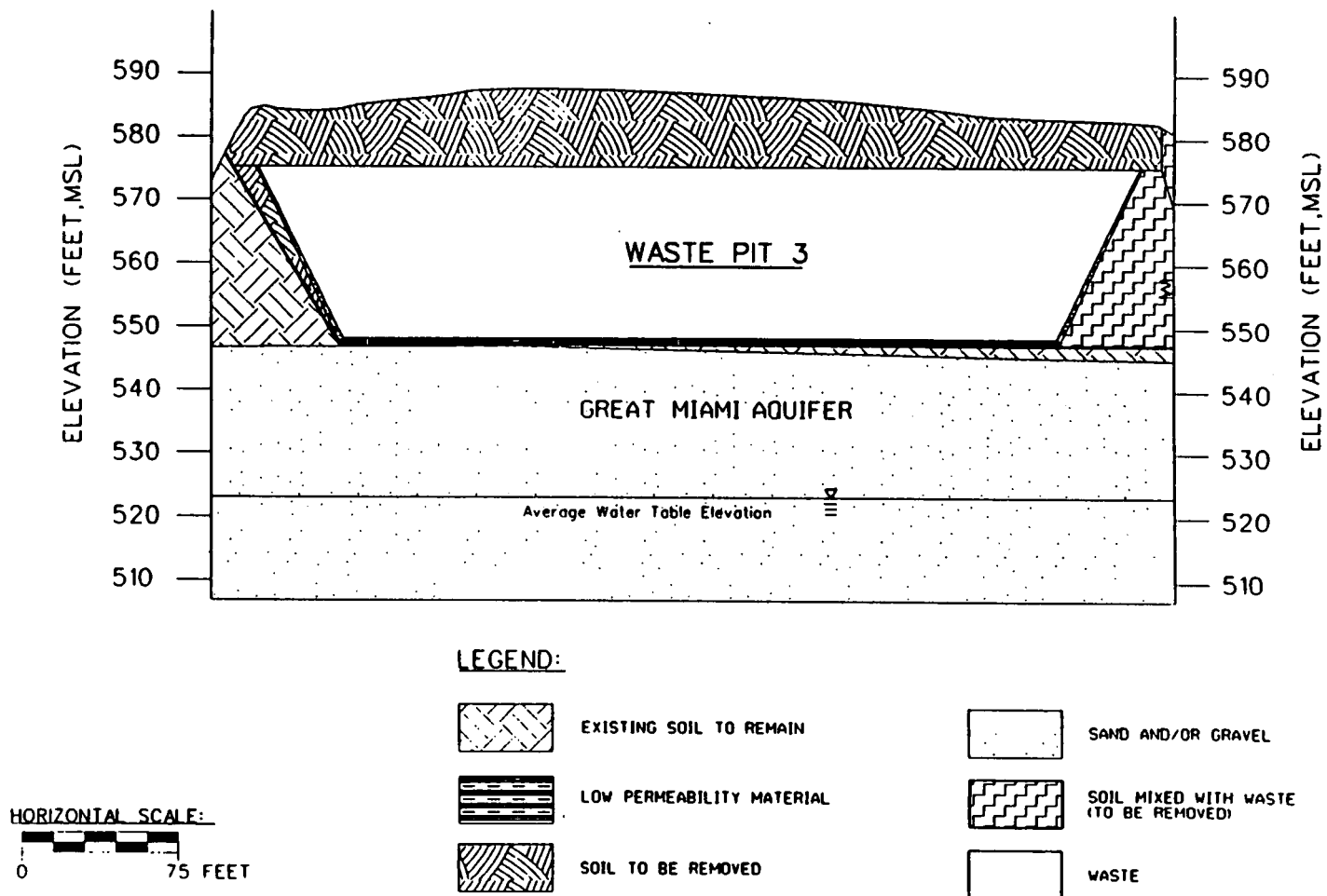
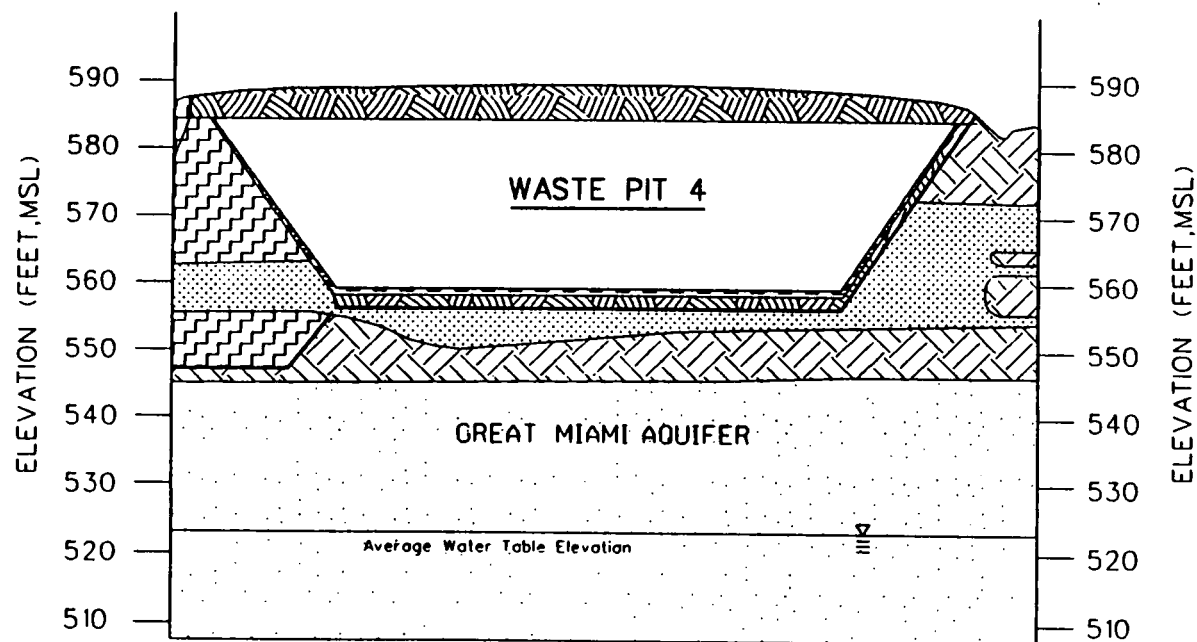


FIGURE D.3-8. CONCEPTUAL DIAGRAM OF OPERABLE UNIT 1 - PIT 3

D-3-80

0188



LEGEND:



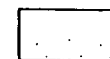
EXISTING SOIL TO REMAIN



LOW PERMEABILITY MATERIAL



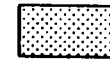
SOIL TO BE REMOVED



SAND AND/OR GRAVEL



SOIL MIXED WITH WASTE
(TO BE REMOVED)



SAND STRINGER



WASTE

HORIZONTAL SCALE:



FIGURE D.3-9. CONCEPTUAL DIAGRAM OF OPERABLE UNIT 1 - PIT 4

4287

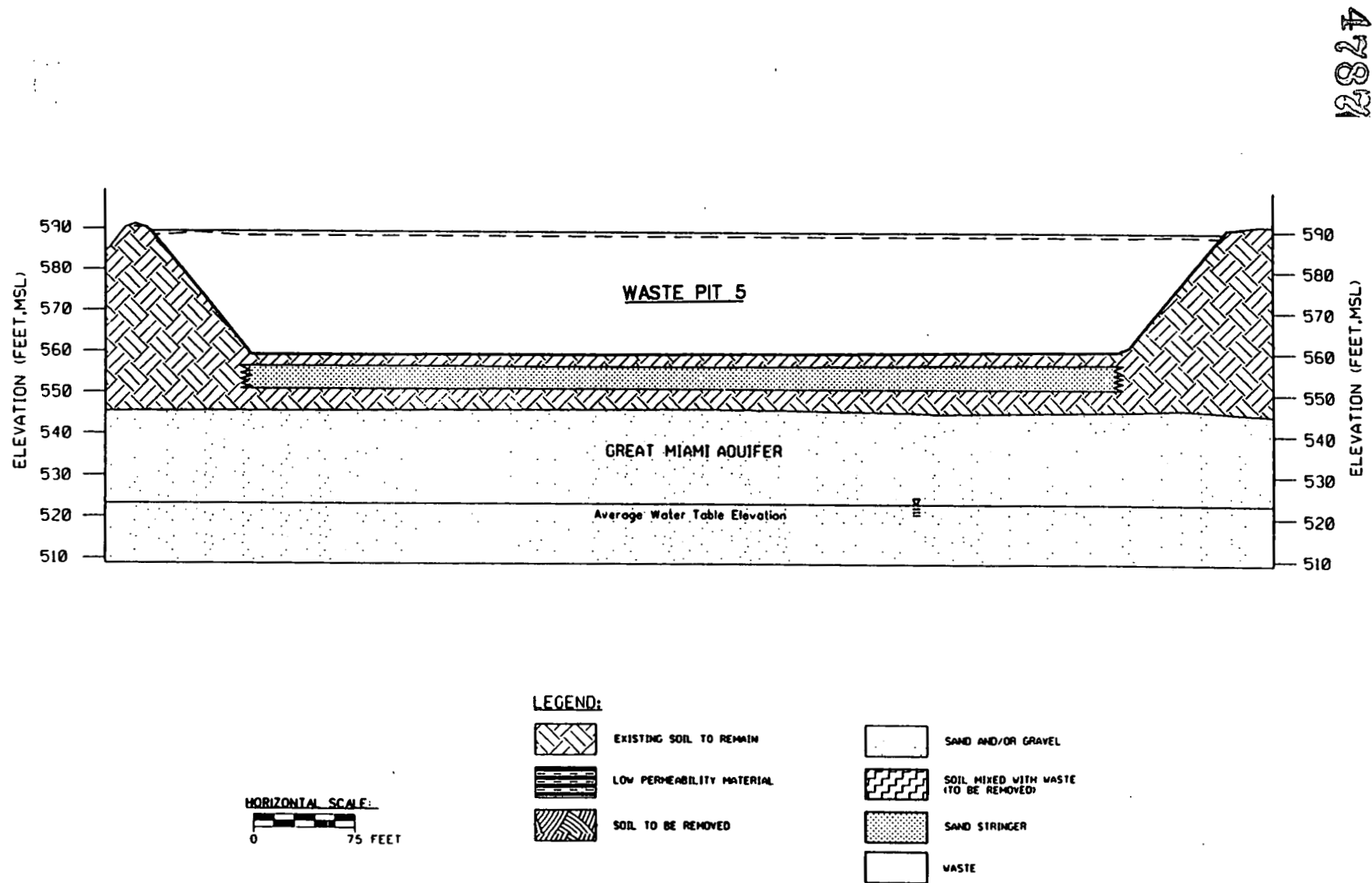


FIGURE D.3-10. CONCEPTUAL DIAGRAM OF OPERABLE UNIT 1 PIT 5

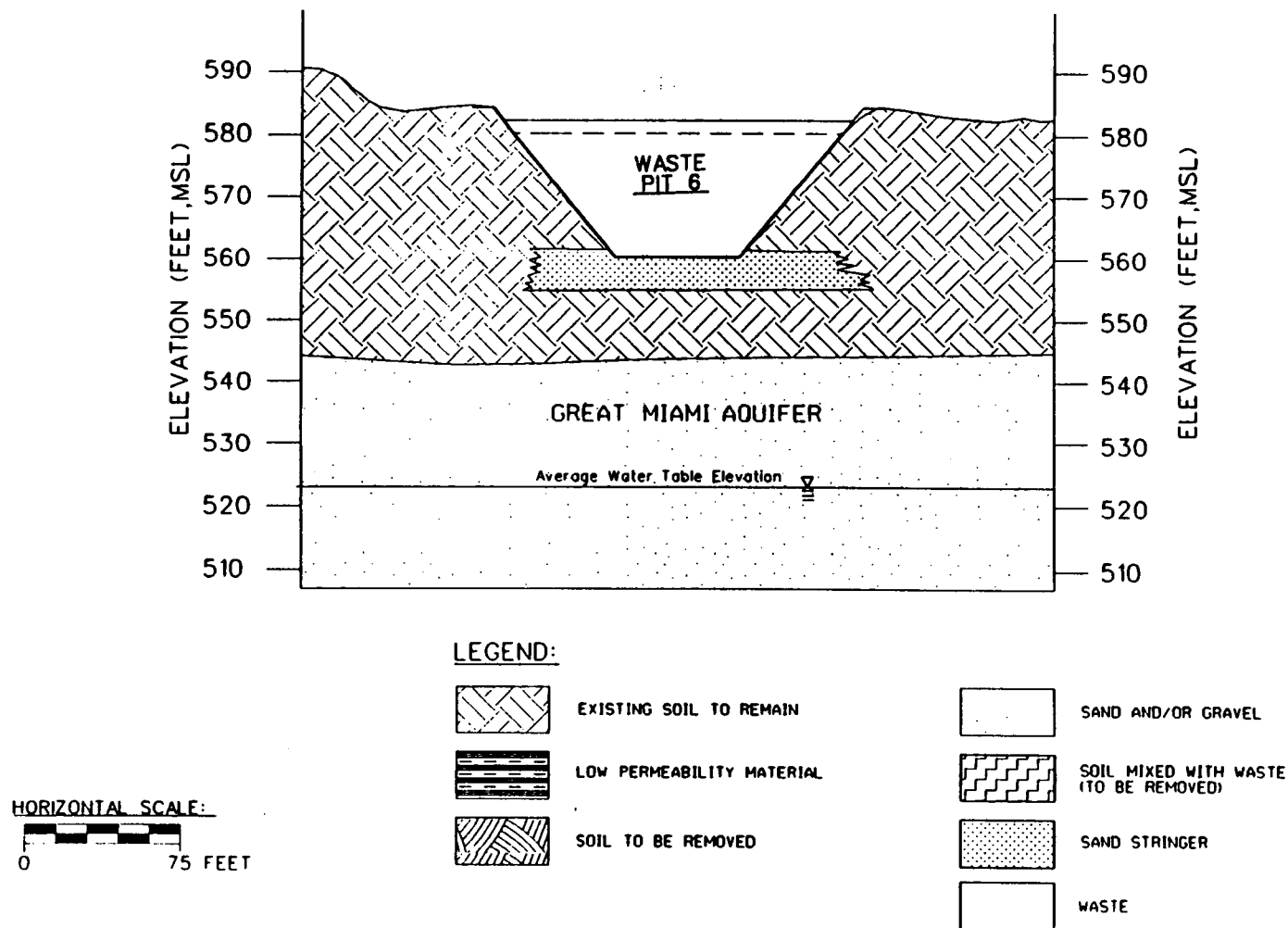


FIGURE D.3-11. CONCEPTUAL DIAGRAM OF OPERABLE UNIT 1 - PIT 6

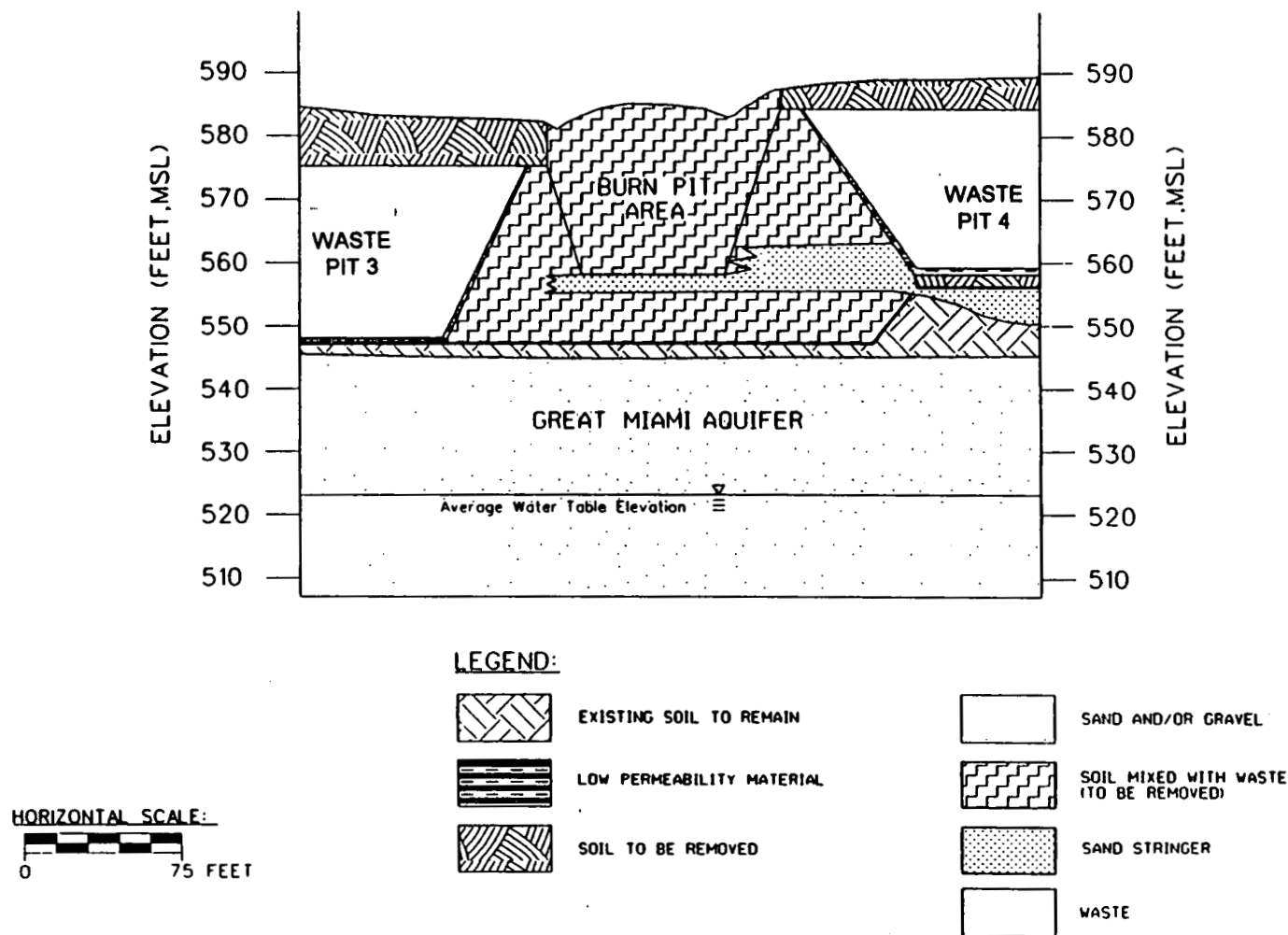


FIGURE D.3-12. CONCEPTUAL DIAGRAM OF OPERABLE UNIT 1 - BURN PIT

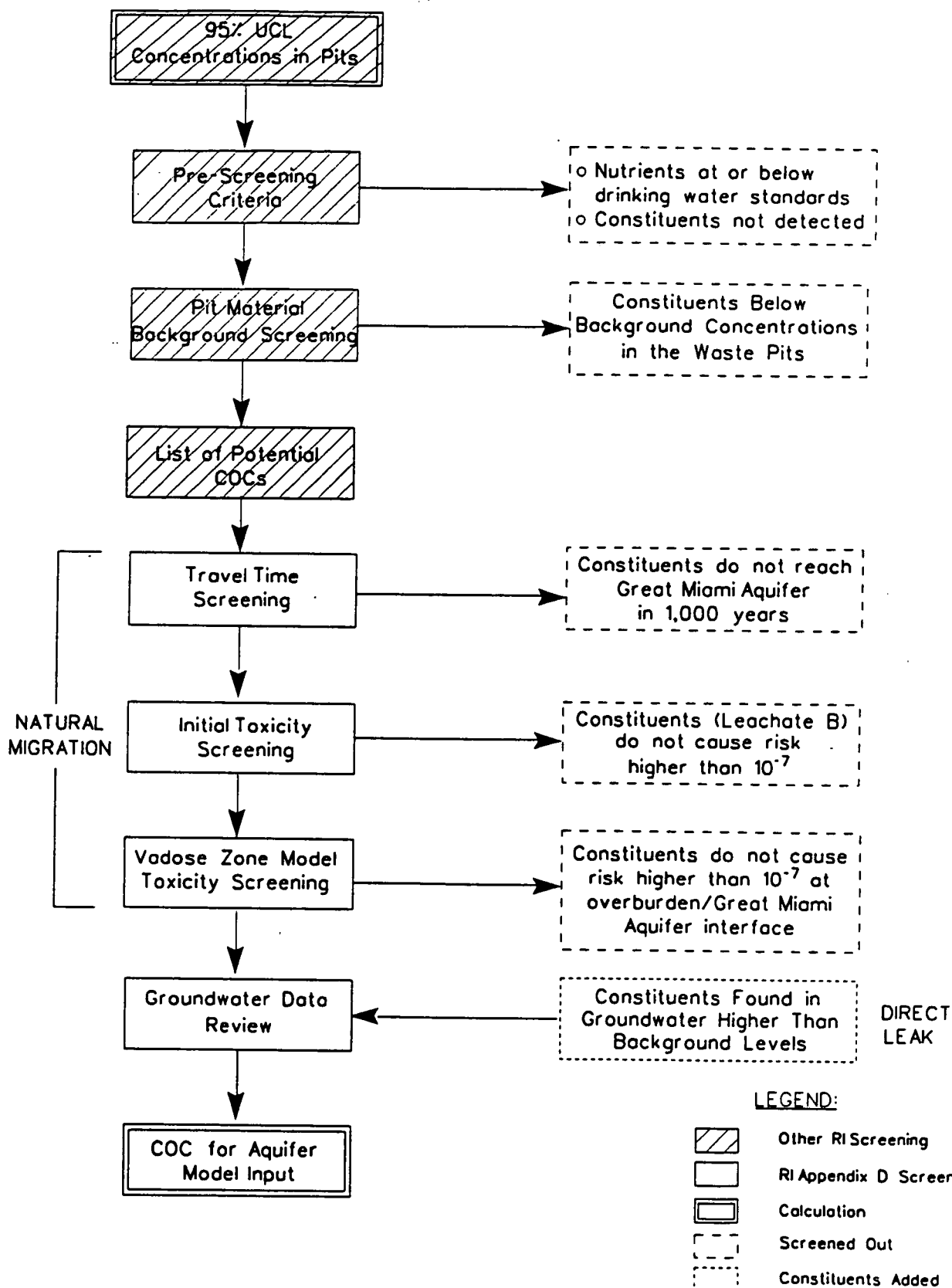


FIGURE D. 3-13. POTENTIAL CONSTITUENT OF CONCERN SCREENING DIAGRAM

SKX02082-A OUT FAIR
SKX02082.DGN 08/06/93 RM

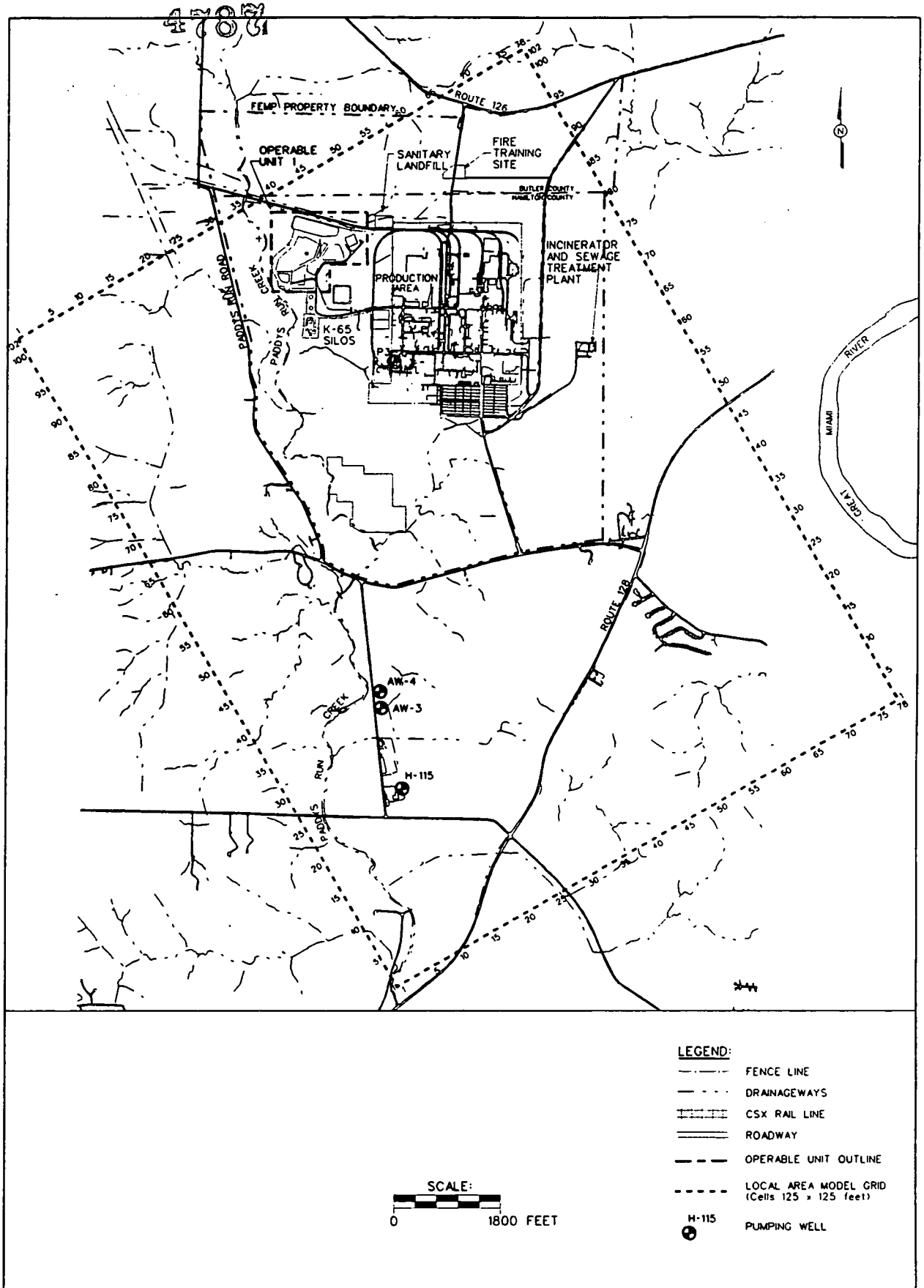
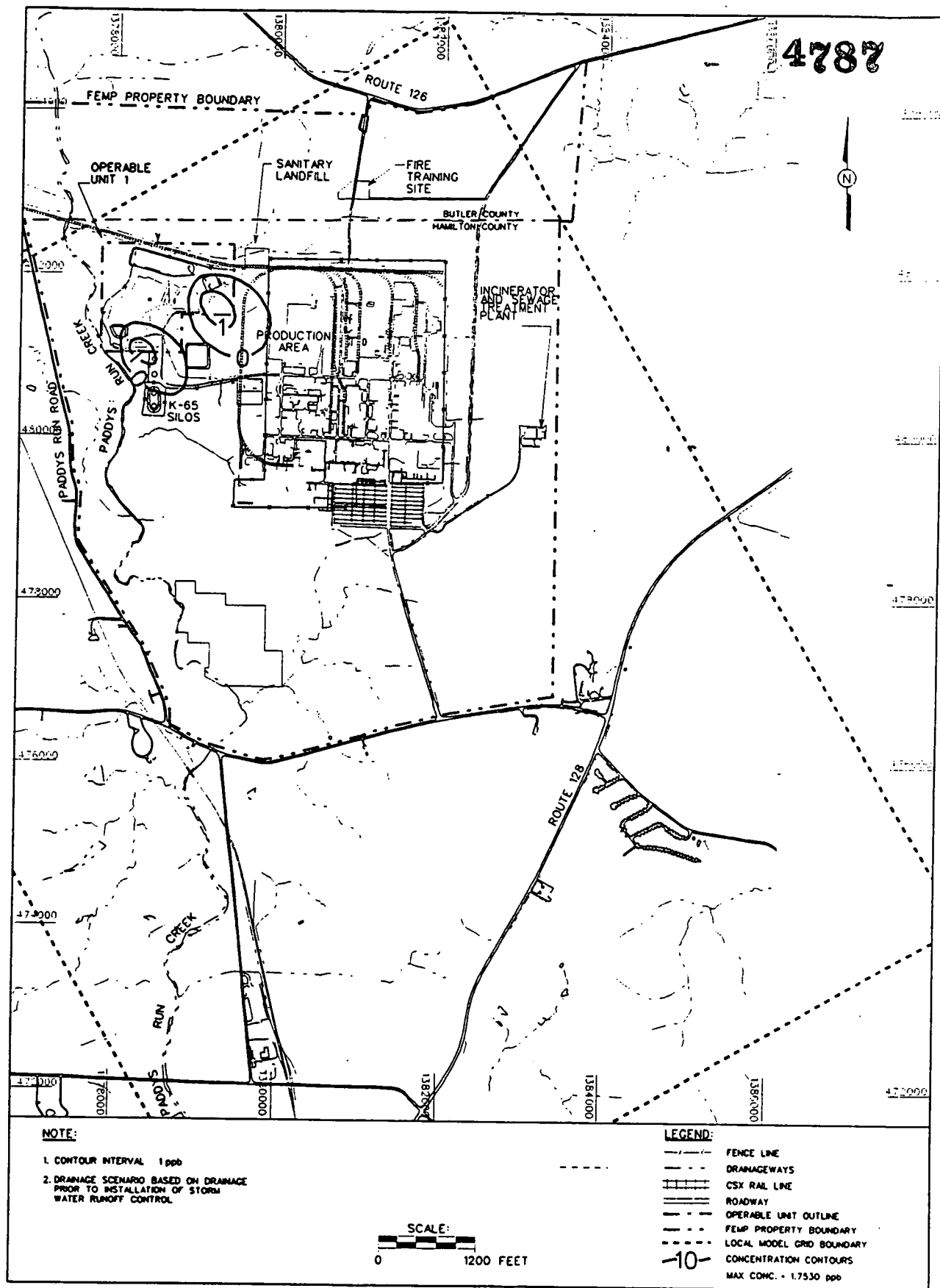


FIGURE D.3-14 SWIFT III LOCAL AREA MODEL GRID

SKX02084-A DUT FAIR
SKX02084.DGN 08/06/93 JE



SKX02085-A OUI FAR
SKX02085.DGN 08/06/93 JE

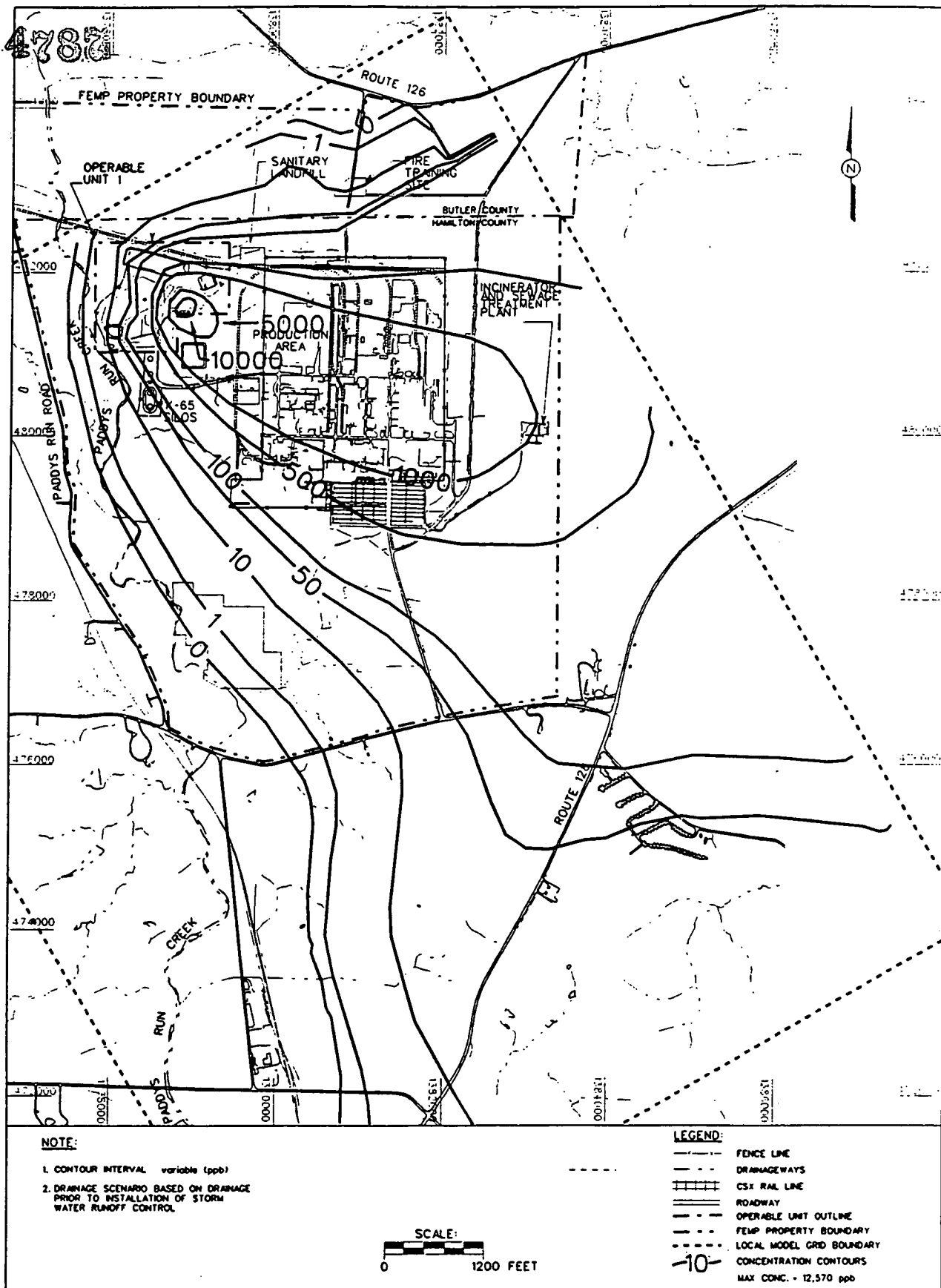


FIGURE D.3-16. PROJECTED MAXIMUM CONCENTRATION OF TOTAL URANIUM IN GROUNDWATER BENEATH FEMP DUE TO LOADING FROM OPERABLE UNIT 1 WASTE AREAS AFTER 630 YEARS

SKX02086-A OU1 FAIR
SKX02086.DCN 08/06/93 JE

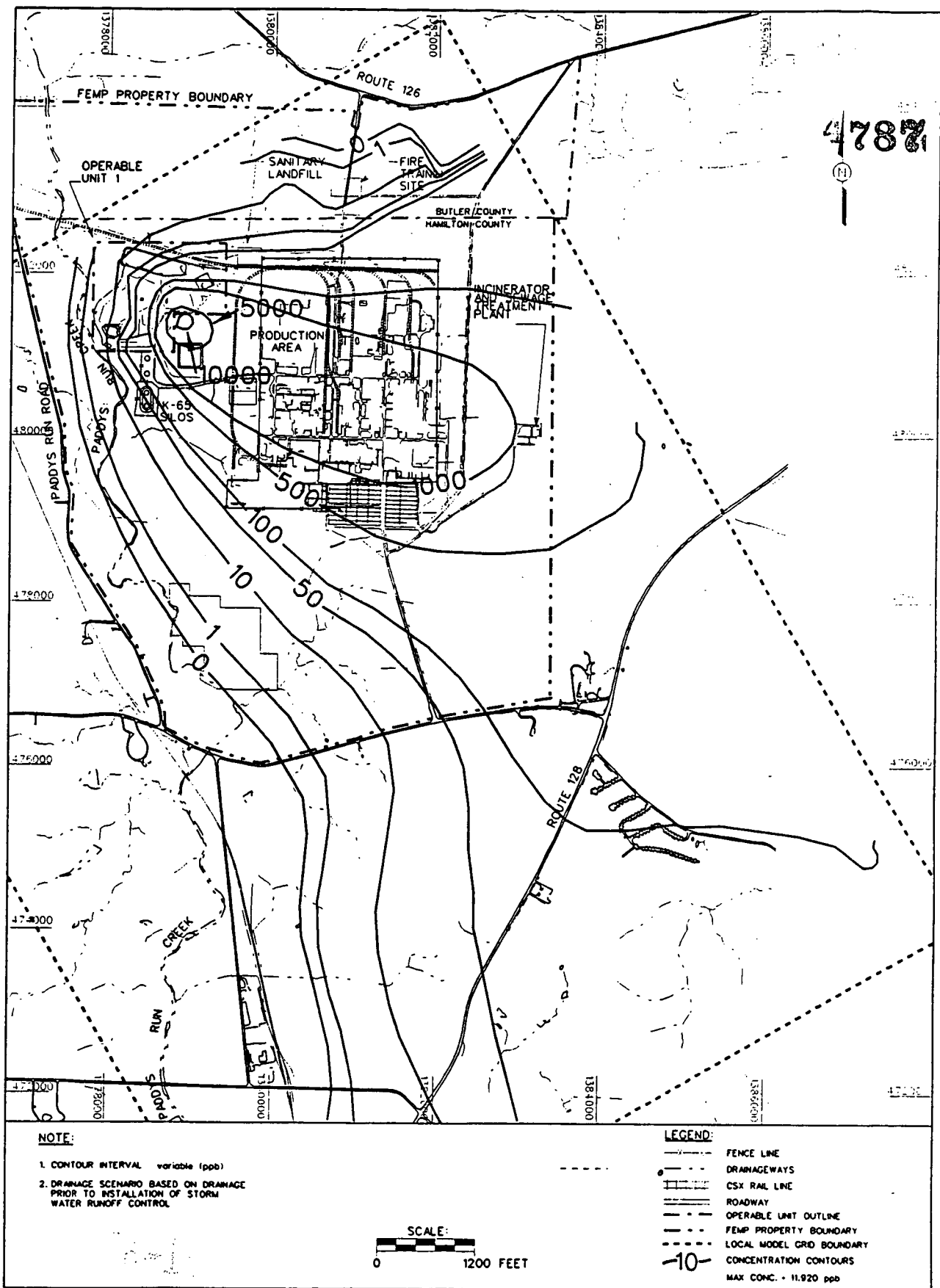
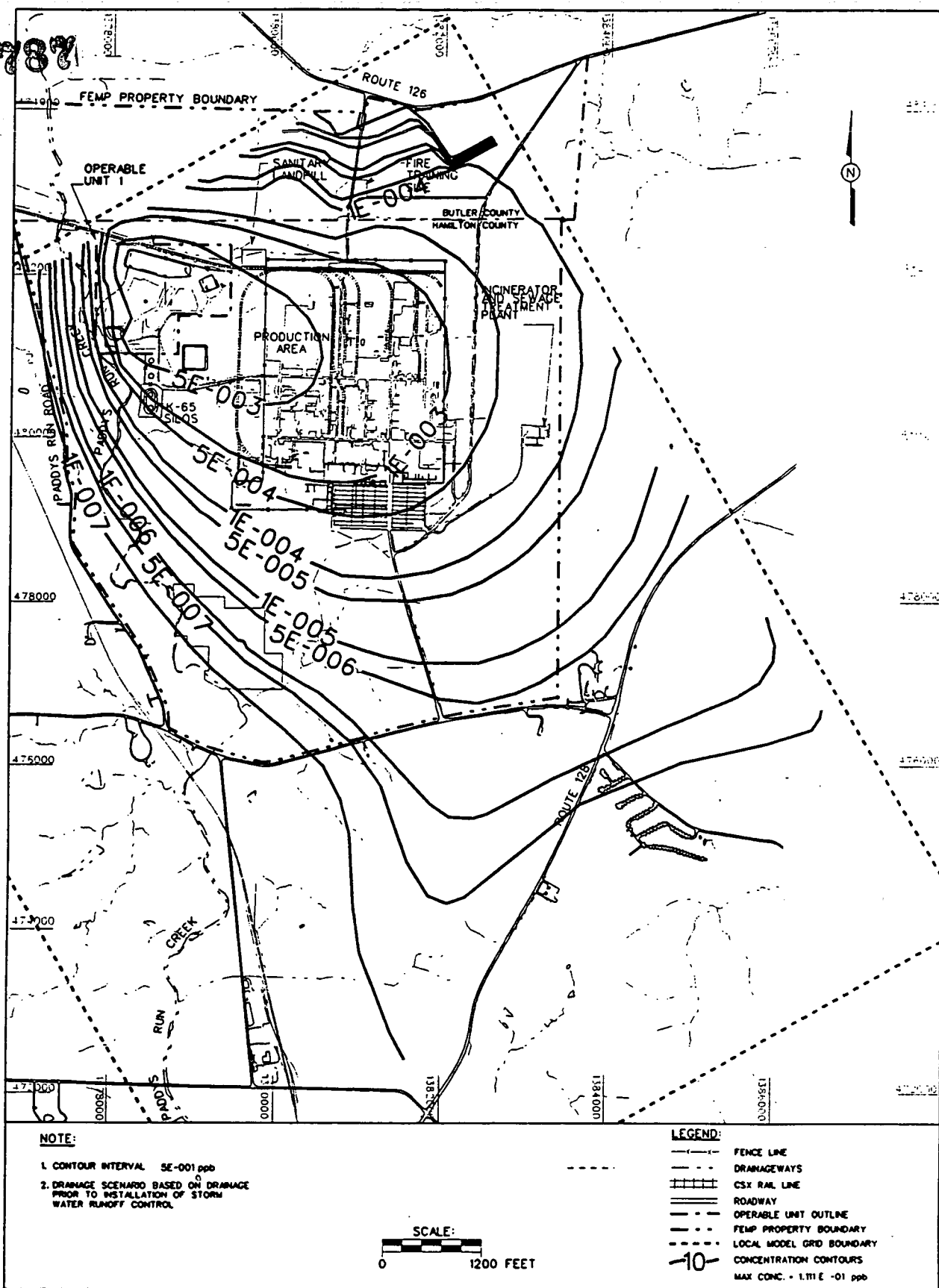


FIGURE D.3-17. PROJECTED CONCENTRATION OF TOTAL URANIUM IN GROUNDWATER BENEATH FEMP AFTER 1000 YEARS DUE TO LOADING FROM OPERABLE UNIT 1 WASTE AREAS

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SKX02090-A OUI FMP
SKX02090.DGN 08/06/93 JE

FIGURE D.3-18. PROJECTED CONCENTRATION OF CYANIDE IN GROUNDWATER BENEATH FEMP AFTER 100 YEARS DUE TO LOADING FROM OPERABLE UNIT 1 WASTE AREAS

0197

SKX02091-A OUI FAR
SKX02091.DGN 08/06/93 JE

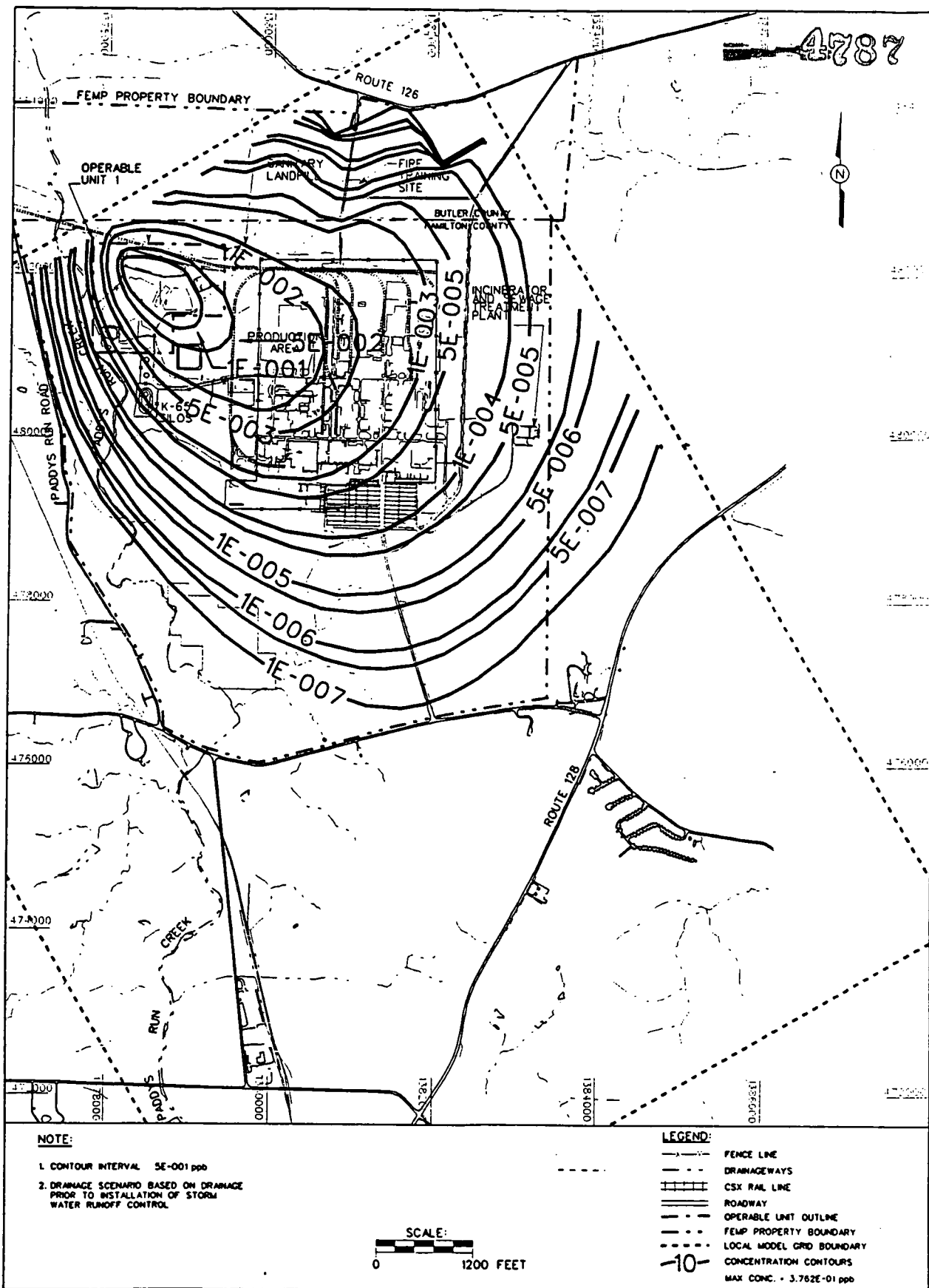


FIGURE D.3-19. PROJECTED MAXIMUM CONCENTRATION OF CYANIDE IN GROUNDWATER BENEATH FEMP DUE TO LOADING FROM OPERABLE UNIT 1 WASTE AREAS AFTER 15 YEARS

SKX02092-A OUT FAIR
SKX02092.DGN 08/06/93 JE

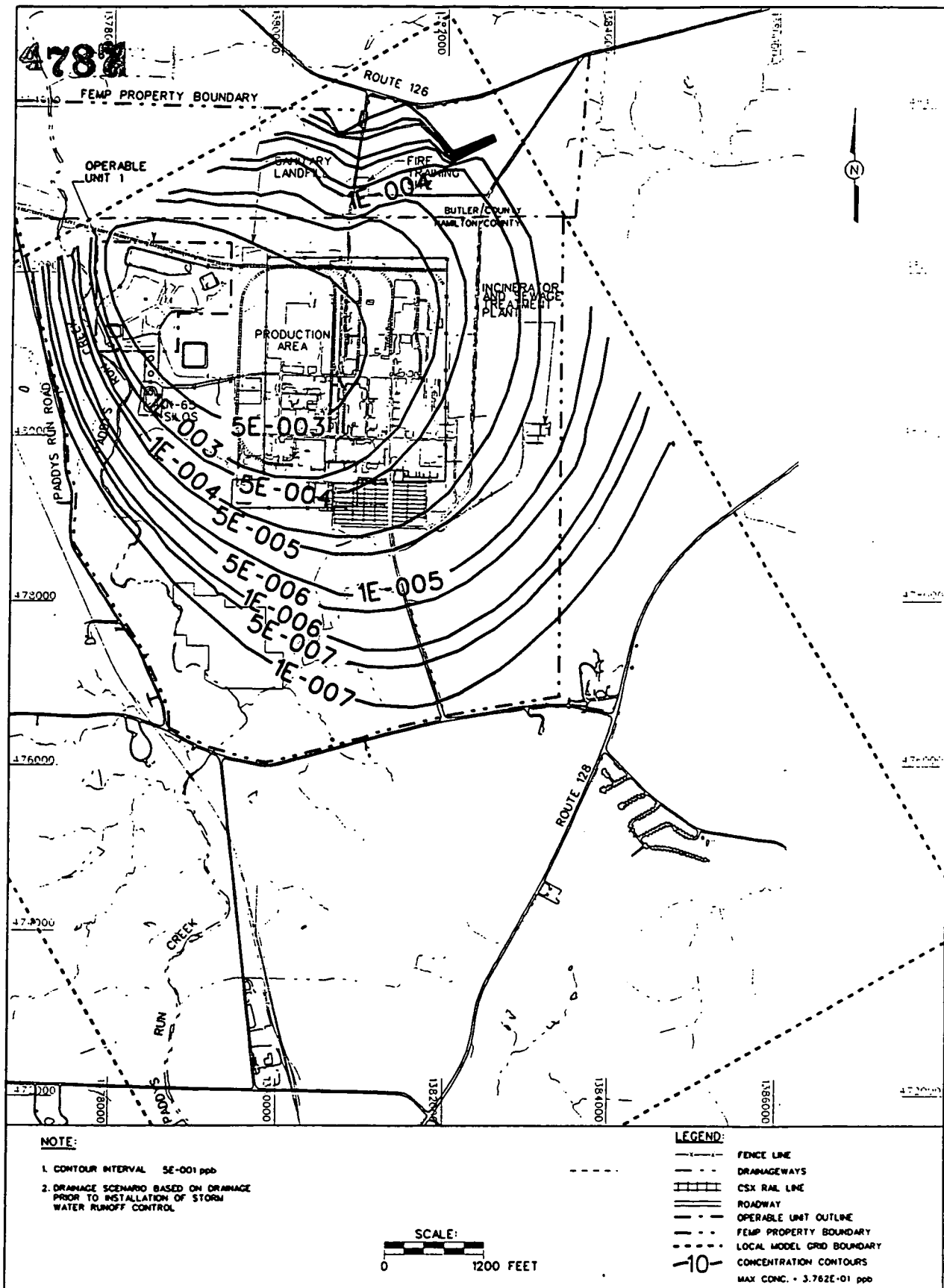


FIGURE D.3-20. PROJECTED CONCENTRATION OF CYANIDE IN GROUNDWATER BENEATH FEMP AFTER 1000 YEARS DUE TO LOADING FROM OPERABLE UNIT 1 WASTE AREAS

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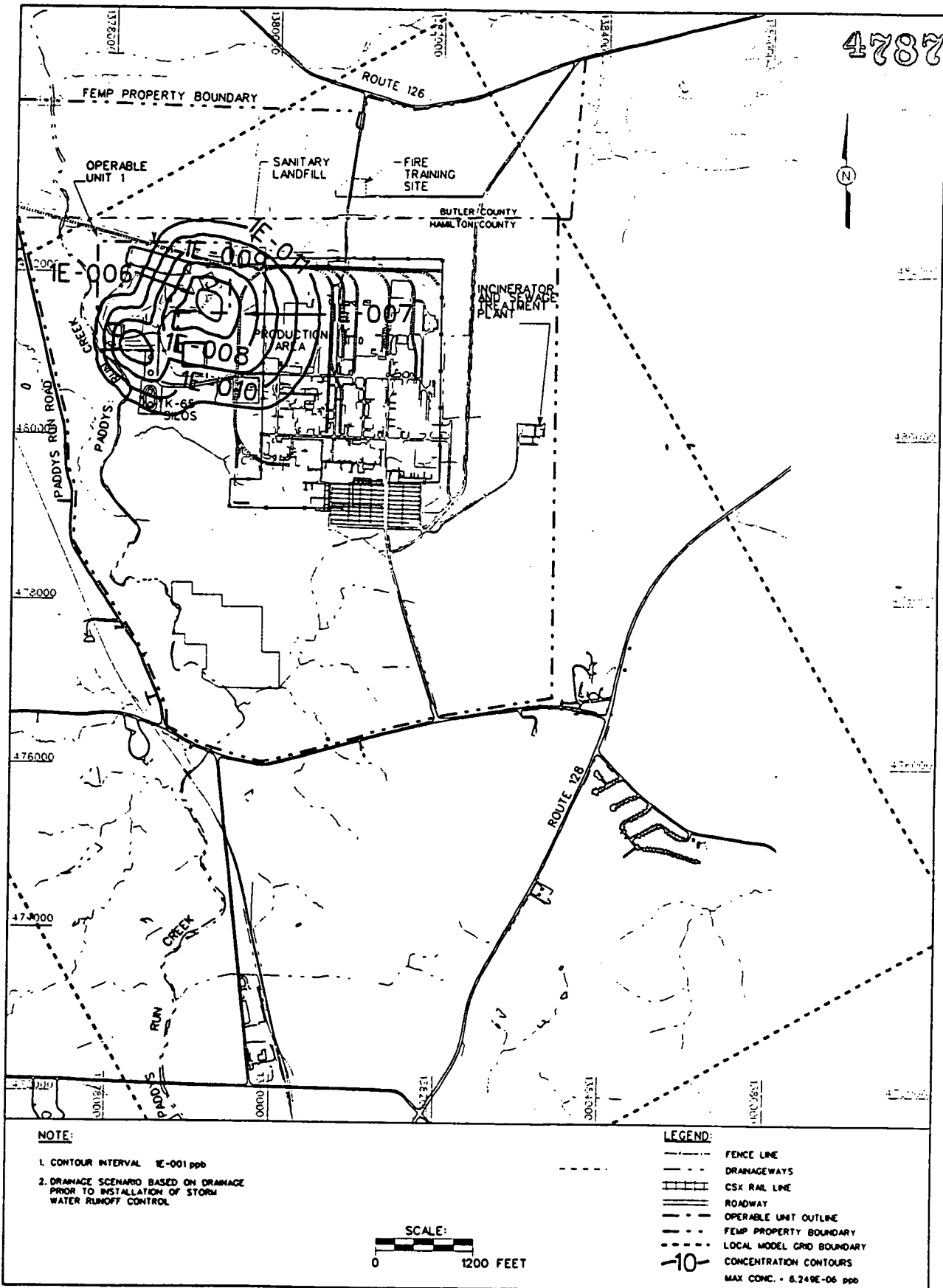
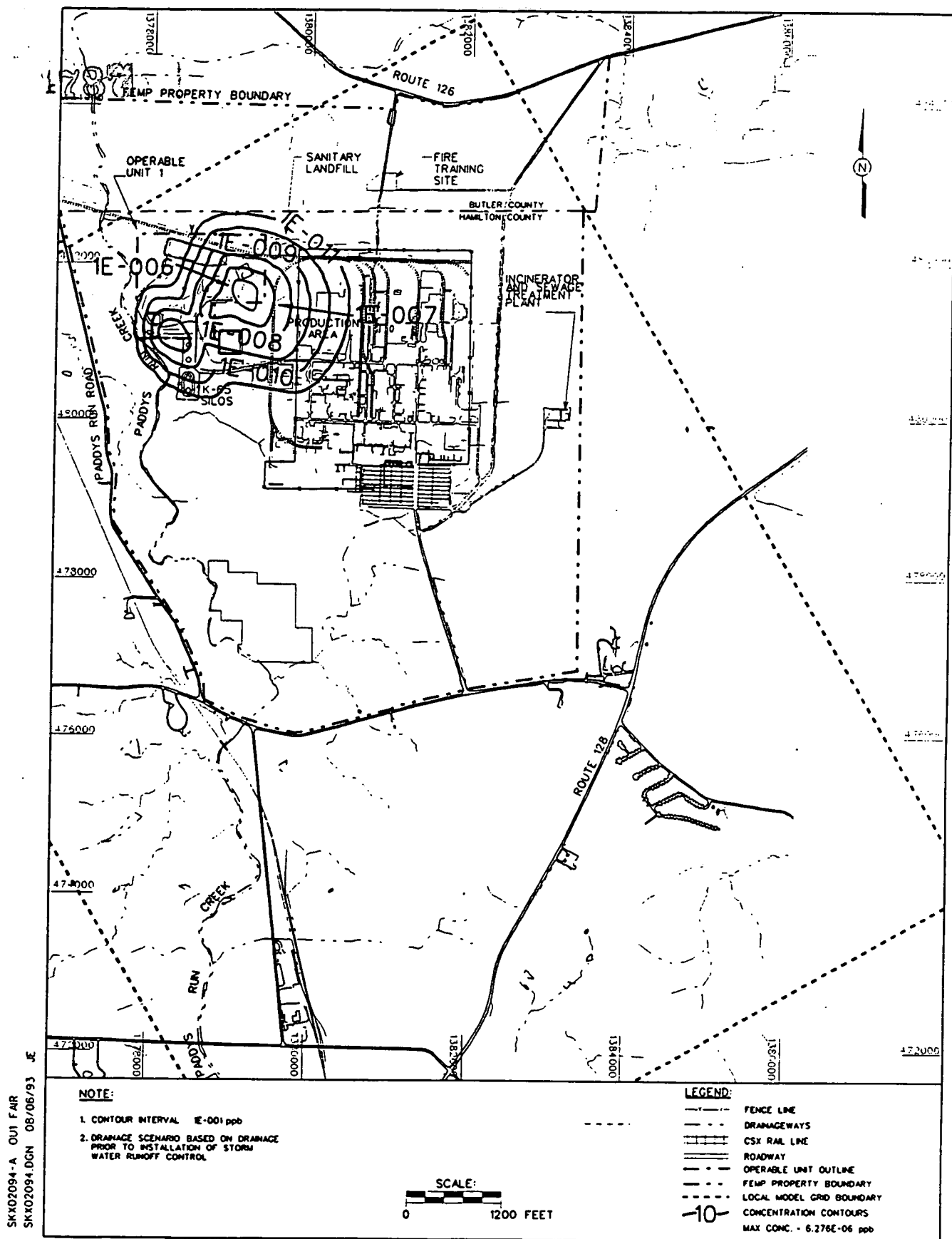


FIGURE D.3-21. PROJECTED CONCENTRATION OF TETRACHLOROETHENE IN GROUNDWATER BENEATH FEMP AFTER 100 YEARS DUE TO LOADING FROM OPERABLE UNIT 1 WASTE AREAS

SKX02093-A OUI FAIR
SKX02093 DGN 08/06/93 JE



SKX02095-A OUI FAIR
SKX02095.DGN 08/06/93 JE

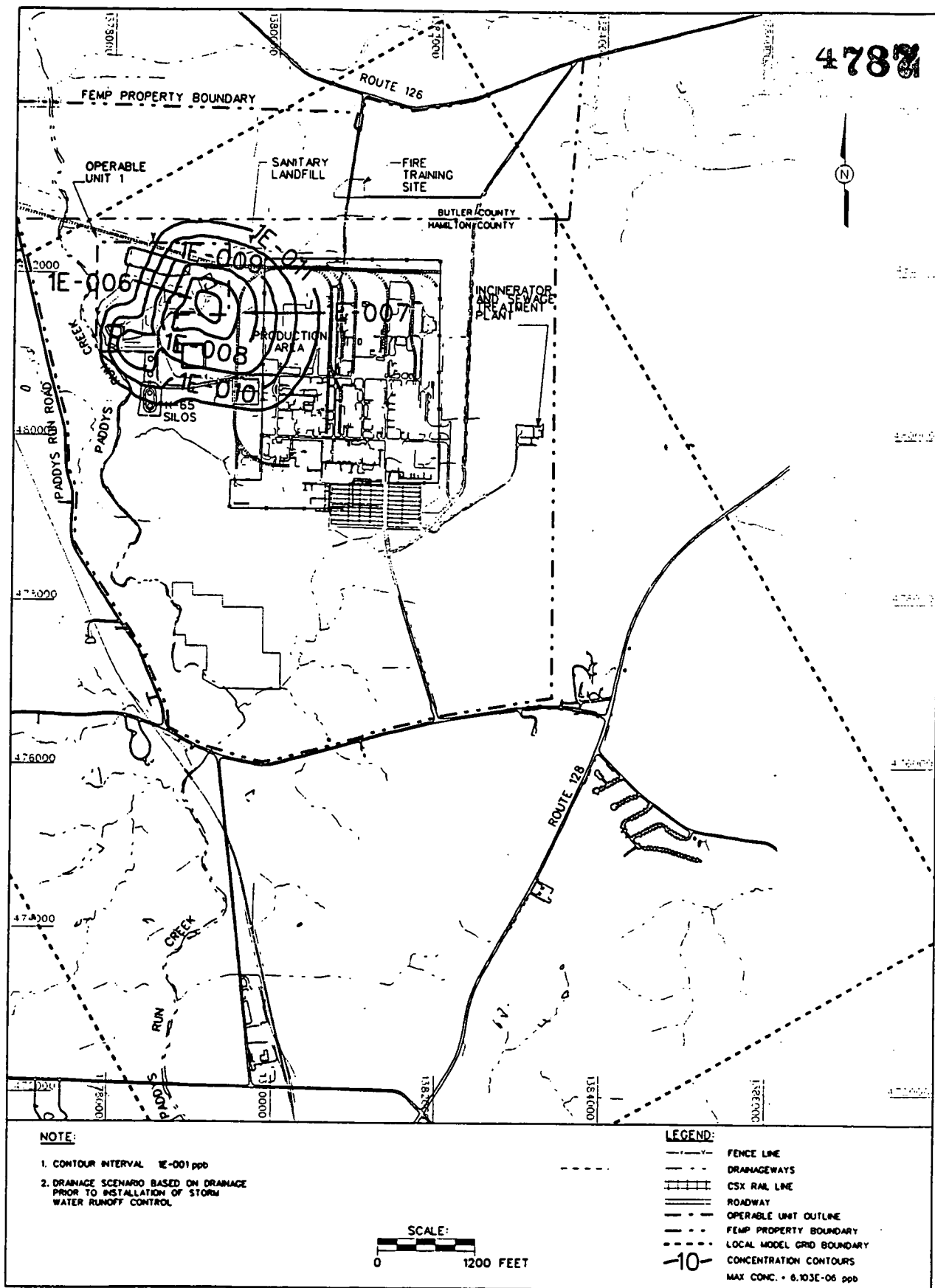
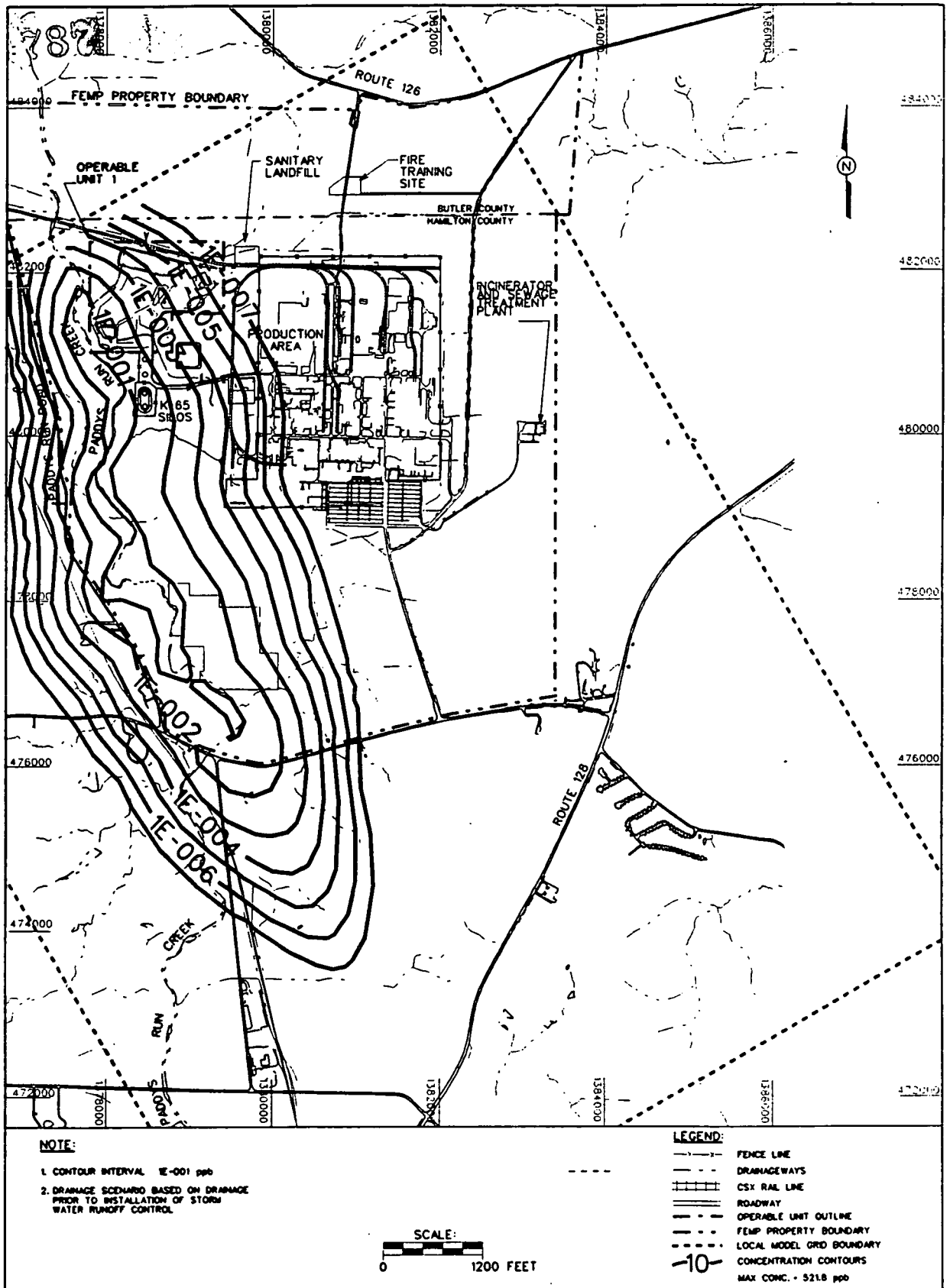


FIGURE D.3-23. PROJECTED CONCENTRATION OF TETRACHLOROETHENE IN GROUNDWATER BENEATH FEMP AFTER 1000 YEARS DUE TO LOADING FROM OPERABLE UNIT 1 WASTE AREAS

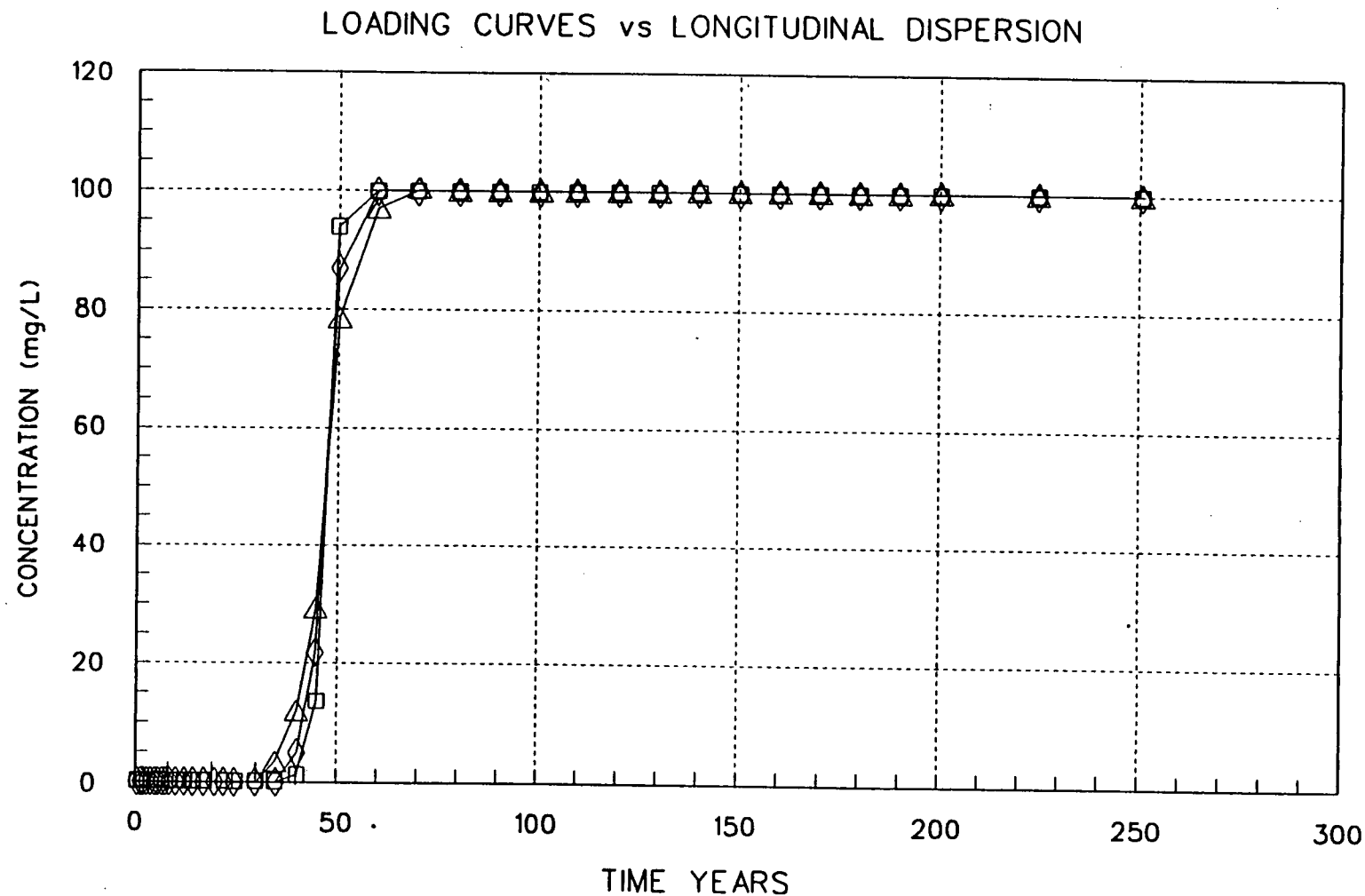
SKX02088-A OUI FAR
SKX02088.DGN 08/06/93 JE



D-3-96

0204

SKX02096-A OUT FAR
SKX02096.DCN 08/06/93 RM



NOTE:

RIQU4 REPORT, 3-93, FIGURE E2-22.

LEGEND:

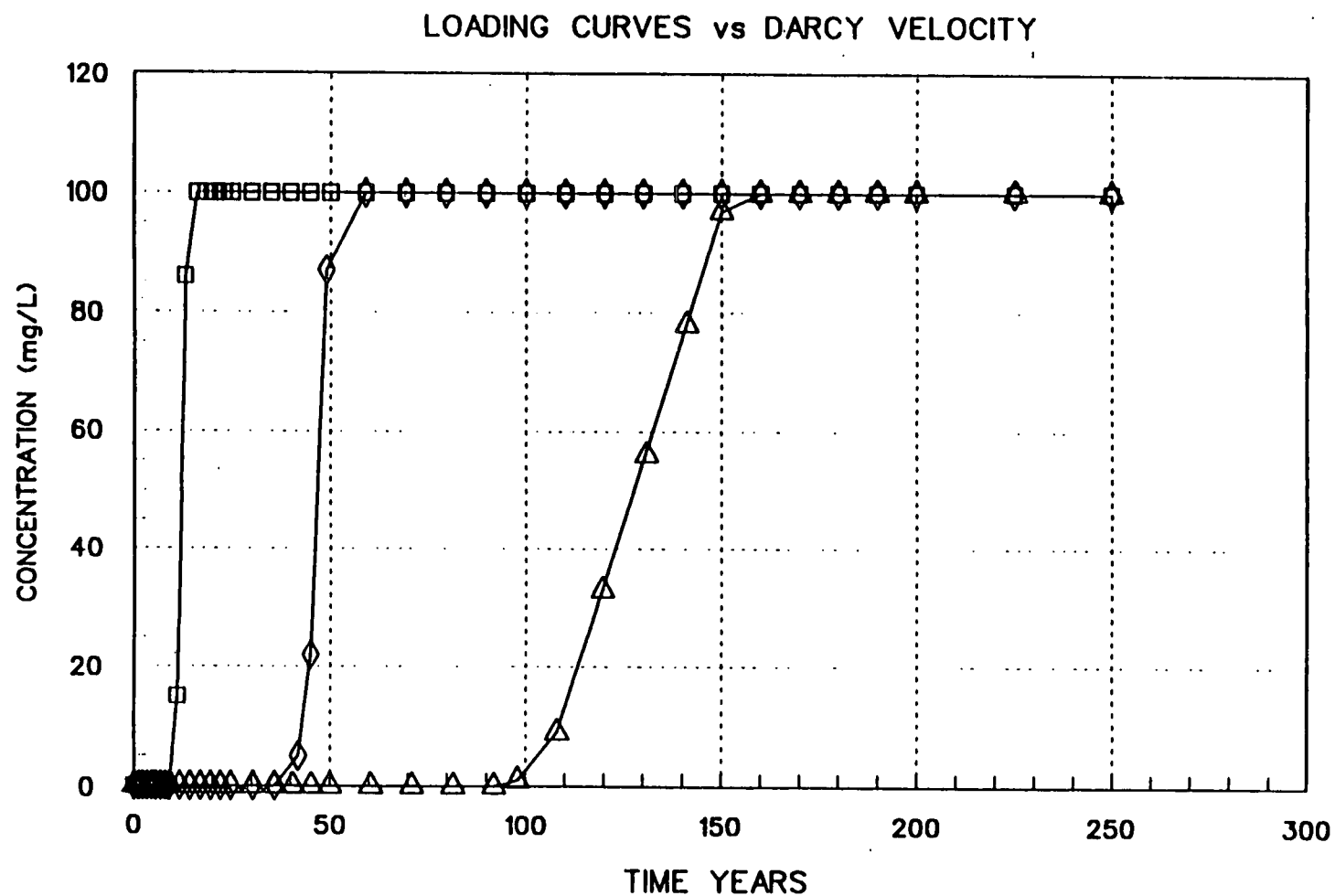
- 1/2x DISPERSION
- ◇ 1x DISPERSION
- △ 2x DISPERSION

FIGURE D.3-25. ODAST MODEL SENSITIVITY ANALYSIS; LONGITUDINAL DISPERSION

4782

D-3-97 0205

30 25/01/50 11:46:07
S2/ XONV/100:12-V-26607



NOTE:

RI 004 REPORT, 3-93, FIGURE E2-23.

LEGEND:

- 1/2 x VELOCITY
- ◇ 1 x VELOCITY
- △ 2 x VELOCITY

FIGURE D.3-26. ODAST MODEL SENSITIVITY ANALYSIS: DARCY VELOCITY

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D-3-98

SK02098-A OUT FAR
SK02098.DCN 08/06/93 RM

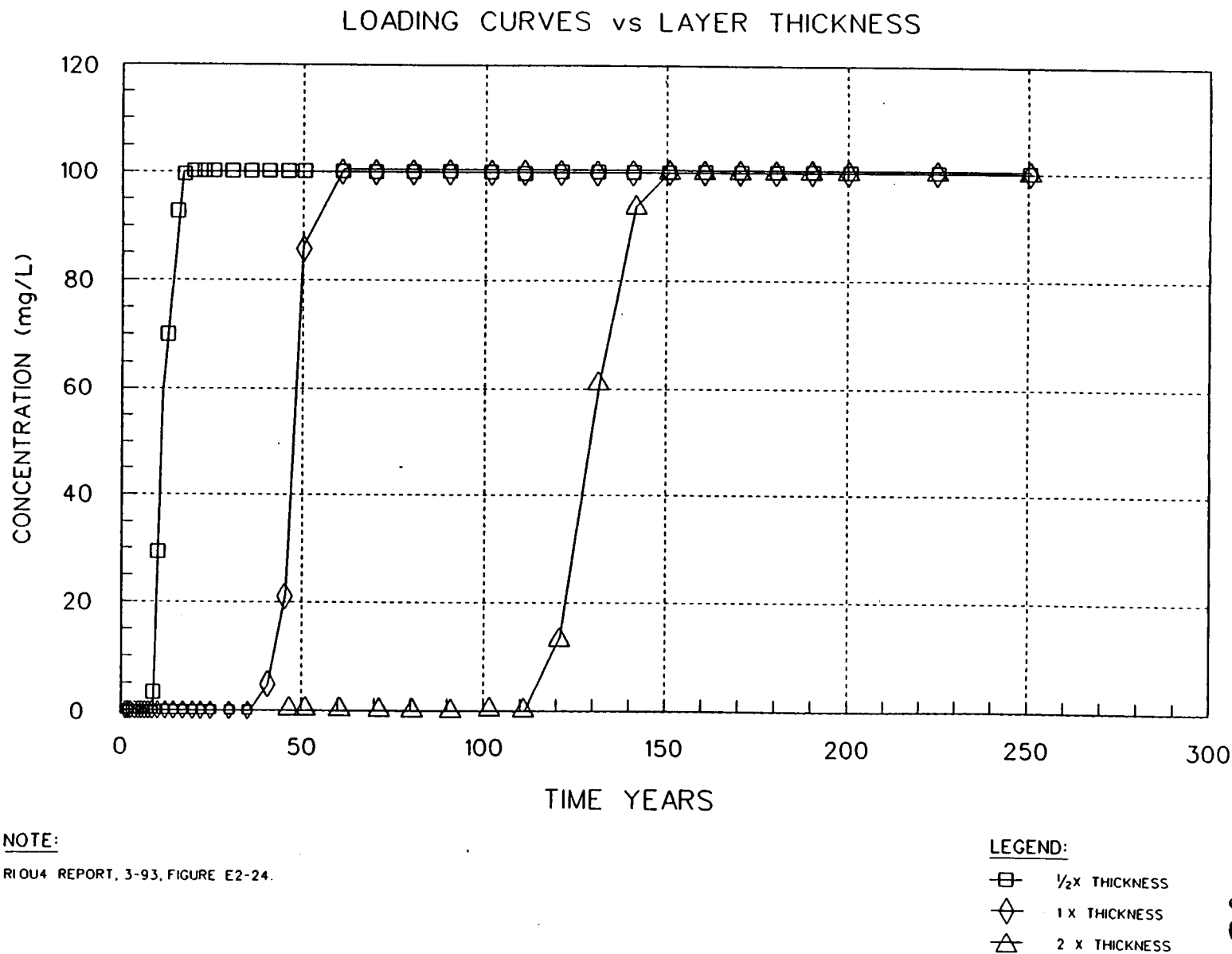


FIGURE D.3-27. ODAST MODEL SENSITIVITY ANALYSIS: ISP LAYER THICKNESS

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APPENDIX D.4.0

AIR

0207

APPENDIX D.4.1
ESTIMATION OF RADON EMISSION FLUX
RAECOM MODEL

ESTIMATION OF RADON EMISSION FLUX RAECOM MODEL

4787

The emission flux of radon gas (radon-222) was modeled using the computer model RAECOM (NRC 1984). RAECOM is a radon generation and transport code that was originally designed to analyze radon generation and emanation through uranium mill tailings waste and earthen cover materials.

RAECOM is used in RI and FS risk assessments to analyze radon generation and emanation through media including waste materials at the FEMP and cover materials such as soil, clay, and concrete. Media-specific parameter values are used. It is acknowledged that the use of a model for scenarios that are different from those for which it was originally designed introduces uncertainty in the results. Thus, the results will be used in operable unit RI and FS risk assessments with an appropriate level of caution.

RAECOM requires input of the thickness of each source material and cover material layer, the source strength expressed either as radium-226 concentration in the waste material or as radon flux exiting the surface of the waste material layer, and the porosity, moisture content, and radon gas diffusion coefficient for each source and cover material layer. The radon flux results are useful for comparison to radon flux criteria or for use in an air dispersion model.

RAECOM calculates the radon flux exiting the surface of the upper layer of cover material. The code is based on a one-dimensional, multilayer solution of Fick's law using the boundary conditions set forth in NUREG/CR-3533 (NRC 1984). For a bare source, this solution becomes:

$$J_i = (10^{-1})(R)(p_i)(E)[(\lambda)(DC_i)]^{1/2}(\tanh [x_i(\lambda/DC_i)^{1/2}]) \quad (D-1)$$

where

- J_i = Radon flux from the source materials surface (pCi/m²-sec)
- R = Specific activity of radium in the source materials (pCi/g)
- p_i = Dry bulk density of source material (g/cm³)
- E = Radon emanation coefficient (unitless)
- DC_i = Radon diffusion coefficient in the total tailings pore space (cm²/sec)
- λ = Radiological decay constant of radon (2.1×10^{-6} sec⁻¹)
- x_i = Thickness of tailings (cm)

In this air transport analysis, emission flux data was required for Waste Pit areas having no soil cover in the future scenario. This included Waste Pits 3, 5, and 6. As a result, equation (1) was used to calculate the emission flux for each Waste Pit. The specific activity of radium-226 for each Waste Pit was obtained from the soils contaminant database. A calculation work sheet, showing the derivation of each Waste Pit's emission flux, is included with this appendix.

0209

RAECOM calculates the radon flux exiting the surface of the upper layer or cover material. For a bare source with no cover material, the radon flux equation becomes:

$$J_r = (10^4)(R)(P)(E)(\lambda)(DC_r)^{1/2} (\tanh[(X_r)(\lambda/DC_r)^{1/2}]) \quad (D-2)$$

where

- J_r = radon flux (pCi/m²-sec)
 R = radium activity
 Waste Pit 3 - 310 pCi/g
 Waste Pit 5 - 110 pCi/g = 8/3/93
 Waste Pit 6 - 4.4 pCi/g
 P_t = dry bulk density (g/cm³) = 1.6 g/cm³ assumed
 E = radon emanation coefficient (unitless) = 0.22
 λ = radiological decay constant of radon = 2.1×10^{-6} sec⁻¹
 DC_r = radon diffusion coefficient (cm²/sec)
 X_r = thickness of tailings (cm) assumed as 100 cm for each Waste Pit

DC_r must be calculated from the following equation:

$$DC_r = 0.007 \exp [-4(M)-(M)(P)^2+(M)^5] \quad (D-3)$$

where

- M = fraction of saturation

M can be determined from the following equation and p = porosity - assumed at 0.41:

$$M = [0.124(p)^{1/2} - 0.0012(E) - 0.04 + 0.156 (F_{cm})] \quad (D-4)$$

where

- p = annual precipitation = 40 inches
 E = annual lake evaporation = 34 inches
 f_{cm} = fraction of soil passing through a 200 mesh sieve assumed at 60 percent
 M = $0.78 - 0.04 - 0.04 + 0.09 = 0.79$

Therefore the radon diffusion coefficient (DC_r) is:

$$\begin{aligned}
 DC_r &= 0.07 \exp [-4(0.79)-(0.79)(.41)^2+(0.79)^5] \\
 &= 0.07 \exp [-3.16 - 0.13 + 0.31] \\
 &= 0.07 \exp [-2.98] \\
 &= 3.56 \times 10^{-3} \text{ cm}^2/\text{sec}
 \end{aligned}$$

Source term calculations for Waste Pits 3, 5, and 6

- Waste Pit 3 = $J_r = (10^4)(310)(1.6)(0.22)(8.65 \times 10^{-5})(0.98367)$
 = 92.85 pCi/m²-sec
 Waste Pit 5 = 32.95 pCi/m²-sec
 Waste Pit 6 = 1.32 pCi/m²-sec

4787

APPENDIX D.4.2

**WIND EROSION EMISSION RATE
CALCULATION**

**ESTIMATION OF PM10 AND TSP EMISSION
RATE DUE TO WIND EROSION**

October 12, 1993

4787

**WIND EROSION EMISSION RATE CALCULATION
ESTIMATION OF PM₁₀ AND TSP EMISSION
RATE DUE TO WIND EROSION**

Objective

To estimate the total suspended particulate (TSP) and PM₁₀ emission rate, from Operable Unit 1 surface materials, due to wind erosion.

Methodology

The "Threshold friction velocity" approach is used for determining the wind erosion rate. The steps in this method are as follows:

- Determine the modal diameter of the sample of soils/ materials.
- Determine the threshold friction velocity of the material based on the modal diameter.
- Determine the mean annual wind speed from the meteorological data.
- Correct the threshold friction velocity at the anemometer height.
- Estimate flux of PM₁₀ due to wind erosion.
- Estimate flux of total suspended particulate based on a particle size multiplier.

Assumptions

1. No continuous vegetation at site.
2. No crust present at this site.
3. No nonerodible elements present at this site.
4. The sieve analysis for Operable Unit 1 surface soil is the same as the sieve analysis of Operable Unit 5 soil.

SolutionModal Diameters of Soils

The modal diameter assumed for Operable Unit 1 surface soil is:

Area	Surface Soil
Modal Diameter (mm)	0.0115

1782 Threshold Friction Velocity

Figure 3-4 of reference 1 (USEPA, 1985) shows the relationship between the threshold friction velocity and the modal diameter of the materials. The analytical equation represented by this log plot is given by:

$$\ln(u_t) = (4.174)[0.415\ln(dp)] \quad (D-5)$$

where

u_t = Threshold friction velocity (cm/s)
 dp = Modal particle diameter of the sample (mm)

This equation has to be extrapolated beyond the ranges of the figure since all modal diameters are below 0.1 mm - the minimum modal diameter on the graph. Extrapolating, the threshold friction velocity was found as:

Area	Surface Soil
Modal Diameter (mm)	0.0115
Threshold Friction Velocity u_t (cm/s)	10.2

Greeley & Iversen (1985) give another method to estimate the threshold friction velocity based on wind tunnel experiments on a number of different materials. The results of the experiment generated a plot of a threshold parameter

$$TF = \frac{\text{SORT}(P_p * g * D_p)}{P}$$

versus the threshold friction velocity u_t (cm/s). In this equation D_p = particle diameter "cm," g is acceleration due to gravity = 981 cm/sec²m, P_p is the particle density (g/cc) and P is the density of air (g/cc). The threshold friction velocity is estimated from this threshold parameter from correlations based on the specific gravity of the sample. The correlation is presented in Figure 3-5 of this reference.

Using the modal diameters as D_p , an average air density of $1.2 * 10^{-3}$ g/cc, the threshold friction velocity by this method is estimated as:

	Surface Soil
Particle day. (cm)	0.00115
Particle density (g/cc)	2.7
Threshold friction Velocity	35

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A summary of the threshold friction velocities determined from both methods is as follows:

	Surface Soil (cm/s)
U.S. EPA Method	10.2
Greeley & Iversen	35

Lowering the threshold friction velocity increases the potential for emission due to wind erosion. Therefore, to be conservative, the lower threshold friction velocity as obtained by the U.S. EPA method will be used to estimate the particulate emission rate for the Operable Unit 1 air assessment.

Since the threshold friction velocity is less than 75 cm/s, Gillette's "Unlimited Erosion Potential" model will be applicable for Operable Unit 1 surface soils.

The friction velocity is determined at the ground surface and will have to be corrected for an anemometer height of 10m. The following equation is used for this purpose (U.S.EPA).

$$U^{* (10)} = U^{* (0)} \frac{1}{0.4} * \ln (10/Z_0) \quad (D-5)$$

Where Z_0 is the roughness of the surface in meters. The Operable Unit 1 modeling protocol assumes a non-vegetated soil cover. The roughness heights for soil covers varies between 1 cm to .1 cm (USEPA, 1985) which correspond to a plowed field and a smooth soil cover, respectively. A conservative roughness height of 1 cm is assumed for the Operable Unit 1 surface soils. The following table presents the friction velocity corrected to a height of 10 m.

	Surface Soil
$U^* \text{ (m/s)}$	0.102
$u_{10} \text{ (m/s)}$	1.76

Application of Gillette's "Unlimited Erosion Potential" model

As mentioned earlier, the Gillette's model is as follows:

$$E_{10} = 0.036 * (1-V) [(U_{10}/U_{10}^*)^3] * F(x)$$

where

- E_{10} = Emission rate of PM_{10} particulate (g/m^2-hr)
- V = Fraction of vegetative cover
- U_{10} = Annual mean wind speed at anemometer height of 10 meters (m/s)

4782

U_{110} = Threshold friction velocity measured at the same height as U (m/s)
 X = $0.886 \cdot [U_{110}/U_{10}]$
 $F(x)$ = A function of 'x'
= 1.91 if $x < 0.5$
= $0.18 (8x^3 + 12x) \text{EXP} (-X^2)$ for $x > 2$
= Figure 4-3 of Reference 1 for $0.5 < x < 2$

The mean annual wind speed obtained from the on-site data collection between 1987 - 1992 are as follows:

Year	1987	1988	1989	1990	1991	1992
Mean Annual Wind Speed	5.1	5.0	4.4	4.5	4.1	4.0
mph (m/s)	(2.28)	(2.235)	(1.967)	(2.011)	(1.833)	(1.788)

Again, to be conservative in predicting the emission rates, the highest of these mean annual wind speed, i.e., 2.28 m/s was selected for the Gillette model.

Based on these input values, the emission flux for Operable Unit 1 surface soil is:

Area	Surface Soil
Emission Flux ($\text{g}/\text{m}^2\text{-s}$) PM_{10}	4.00×10^{-5}

An example calculation is shown below:

U_{110} = 1.76 m/s
 U_{10} = 2.28 m/s
 X = $0.886 \cdot (U_{110}/U_{10}) = .68$

Since "x" is greater than 0.5 but less than 2.0, use Figure 4.3 for $F(x)$.

$F(x)$ = 1.84
 V = 0.0 (assumed that no vegetative cover on material)
 E_{10} = $0.036 \cdot (1 - 0.0) \cdot [(2.28/1.76)^3] \cdot 1.84$
= $0.036 \cdot 1 \cdot 1.84$
= $.144 \text{ g}/\text{m}^2\text{-hr}$
= $.144 \cdot \text{g}/\text{m}^2\text{-hr} \cdot 1/3600 \text{ hr}/\text{sec}$
= $4.0 \times 10^{-5} \text{ g}/\text{m}^2\text{-sec}$

The emission flux for TSP is determined by dividing the emission flux of PM_{10} by a particle size factor (K), where 'K' is the fraction of PM_{10} particulate in the suspended particulate. From data available in the literature, (USEPA, 1985, USEPA 1990) $K = 0.5$, therefore, emission flux of TSP from Operable Unit 1 surface soils is:

$$ER_{TSP} = 4.0 E^{-05} / 0.5 = 8 E^{-05} \text{ g/m}^2\text{-sec}$$

4787

Threshold friction velocity for Waste Pit Materials

In the future scenario Operable Unit 1 will not have a homogenous surface soil cover as assumed in the current scenario. Waste Pits 3, 5 and 6 material will be exposed and available for wind erosion.

A review of available subsurface material geotechnical analyses resulted in the following minimum modal diameters for various Waste Pits. The materials were sampled at depths of 4-7 feet from the surface, i.e., top of the cap material.

	Waste Pit 1	Waste Pit 2	Waste Pit 3	Burn Pit
Modal Diameter (mm)	0.13	.017	.010	.05

Based on this data the modal diameter used to calculate wind erosion emission rates for surface soils (.0115 mm) is representative of the Waste Pit material also. Therefore the calculated PM10 wind erosion emission rate ($4.0 \times 10^{-5} \text{ g/m}^2\text{s}$) will be used in both the current and future scenario for all sources.

4787

APPENDIX D.4.3

**AIR TRANSPORT AND DISPERSION MODELING
PROTOCOL AND RESULTS**

AIR TRANSPORT AND DISPERSION MODELING
PROTOCOL AND RESULTS

4787

Site Description of Operable Unit 1

Operable Unit 1, commonly referred to as the Waste Pit area, is located in the northwest corner of the Fernald Environmental Management Project (FEMP) facility. Surrounding Operable Unit 1 is the Production Area to the east, the K-65 silos to the south and Paddys Run to the west. There are 8 individual Waste Pits in Operable Unit 1 which are identified as Waste Pits 1 through 6, the Burn Pit and Clearwell. The location of these Waste Pits are shown in Figure 5-15. Aerial photographs of Operable Unit 1 taken in December 1988 and March 1992 show that Waste Pits 1 through 3 and the Burn Pit have been backfilled and are covered with vegetation. Waste Pit 4 is protected by a temporary RCRA cover. The remaining Waste Pits are filled with water.

From U.S Geological Survey topography maps (Southeast Ohio, Shandon Quadrangle, revised 1981) topographic characteristics surrounding the Waste Pits is generally flat. The only major topographic feature is the Great Miami River which is located approximately one mile, at its closest point, east of the FEMP facility. Recent aerial photographs show vegetation, in the form of needle and broadleaf trees, growing to the north and west of Operable Unit 1. Isolated dairy and agricultural farms also surround the FEMP facility.

Conceptual Air Model Source Scenarios

The conceptual model for the Operable Unit 1 air transport analysis examined two emission scenarios. The two scenarios evaluated emissions for current conditions at Operable Unit 1 and a future condition that assumed the site is a part of a homestead. These scenarios are briefly discussed below.

Current Scenario Sources

In the current scenario, Waste Pits 1 through 4 and the Burn Pit are assumed to be covered with nonvegetated contaminated soil, which is susceptible to wind erosion. Waste Pits 5, 6 and the Clearwell are filled with water and not considered to be sources of emissions.

Future Scenario Sources

In the future scenario, Waste Pits 1, 2, 4 and the Burn Pit are covered with contaminated soil and susceptible to wind erosion. However, Waste Pits 1 and 2 are assumed to be irrigated and used to grow crops for human and animal consumption. Crops are assumed to vegetate the local area approximately six months out of the year, therefore a 50% vegetation cover is assumed for Waste Pits 1 and 2.

4787
Also in the future scenario, the left half of Waste Pit 5 and the right half of Waste Pit 6 are filled with water. Therefore, Waste Pit material which fills the right half of Waste Pit 5 and the left half of Waste Pit 6 is exposed and susceptible to wind erosion. The Clearwell remains filled with water and is not considered an emission source in the future scenario.

The soil cover on Waste Pit 3 is assumed to fail, thus exposing Waste Pit 3 material to wind erosion.

Air Dispersion Model

Annual average ground level concentrations were determined by the USEPA's computerized Industrial Source Complex Long-Term (ISCLT2) model, Version 92273. This model was specified for use in the "Risk Assessment Work Plan Addendum", Section 6.0, dated June 1992.

The ISCLT2 model is designed for assessing the air quality impact of emissions at user-selected receptors from a variety of sources. It incorporates a steady-state Gaussian plume equation that is applicable for flat or gently rolling terrain. The ISCLT2 model calculates annual average ground level concentrations or deposition due to airborne emissions at user-selected receptors, based on sector averaged statistical wind summaries known as STatistical ARrays (STAR). The user can select from single or multiple point, area or volume sources as input to the model. Input data also includes emission rates of the sources, the location and configuration of sources, statistical summaries of wind speed, wind direction and atmospheric stability, and the locations of receptors of interest. Other input options used in the modeling are addressed in Table D.4-1.

Input Parameters

Meteorological Data

Five meteorological parameters: wind speed, wind direction, ambient air temperature, atmospheric stability and vertical mixing heights are required as input for the ISCLT2 model. All parameters, with the exception of vertical mixing heights, are measured directly at FEMP's on-site meteorological tower. Vertical mixing heights were calculated from atmospheric sounding data compiled twice daily, from the National Weather Service (NWS) in Dayton, Ohio (See Table D.4-2). The NWS office in Dayton was selected because it was the closest source of atmospheric sounding data to the FEMP facility. It was assumed that atmospheric conditions recorded at the NWS Dayton office would best represent the conditions at the FEMP facility.

Wind speed, wind direction and ambient air temperature data are measured at the FEMP meteorological tower at a height of 10 meters. The atmospheric stability category is derived from direct measurements of the standard deviation of the horizontal wind direction (sigma-theta) during the daytime and the low-level temperature difference (delta-T) at night. These procedures are in accordance with U.S. EPA methodology for estimating Pasquill stability categories in terms of the

standard deviation of the horizontal wind direction and low level temperature differences, (EPA Publication 450/4-87-013 "On Site Meteorological Program Guidance for Regulatory Modeling Applications", Section 6.0). The temperature difference is calculated from air temperature recorded at the 60 meter and 10 meter levels.

The ambient air temperatures measured at the FEMP meteorological tower and the temperatures used in the ISCLT2 model as a function of atmospheric stability categories A through F are given in Table D.4-3. Assignments of temperatures to stability categories were made as per U.S. EPA recommendations (U.S. EPA Publication 450/4-92-008a, "Users Guide for the Industrial Source Complex (ISC2) Dispersion Models", Vol. 1, Section 3.5.11). These recommendations suggest that the annual average maximum daily temperatures be assigned to the A, B, and C stability categories, annual average temperature be assigned to the D stability category, and the annual average minimum daily temperature be assigned to the E and F categories.

The format of the meteorological data required by the ISCLT2 model is in the form of the STability ARray (STAR) program output. The STAR program output is a statistical meteorological data summary which gives the joint frequency distribution of six wind speed classes by sixteen wind sectors (i.e. north, north-northeast, northeast etc.) by six atmospheric stability categories (A through F). STAR data for the six years, 1987 through 1992, are listed in Attachment D.I.

The six wind speed classes are defined as 1 to 3 miles per hour (mph); 4 to 7 mph; 8 to 12 mph; 13 to 18 mph; 19 to 24 mph; and greater than 24 mph. Calm winds are wind speeds less than 1 mph with a variable wind direction. To account for the calm winds measured at the FEMP meteorological tower, the frequency of occurrence of calm winds were equally divided among the sixteen wind direction sectors and added to the 1 to 3 mph wind speed class.

According to meteorological wind data measured and recorded at FEMP facility, the prevailing wind direction blows from the southwest to the northeast.

Figures graphically illustrating the meteorological wind profile for each year from 1987 through 1992 are given in Attachment D.II.

Source Data

The ISCLT2 model defines sources as any point(s), area or volume that have the potential to emit emissions. Due to the ground level configuration of the Operable Unit 1 Waste Pits and the large area of potential emissions, all sources were defined as "area" sources. In the current scenario, there were 5 individual area sources used as input into the ISCLT2 model. These sources were Waste Pits 1 through 4 and the Burn Pit. A total of seven individual sources were considered in the future scenarios. These sources include Waste Pits 1 through 6 and the Burn Pit.

0220

One limitation of the ISCLT2 model is its inability to calculate ground level concentrations from irregularly shaped area sources. Therefore, the user is required to breakdown each irregularly shaped source into a series of squares that would best approximate the square area of that source (U.S. EPA Publication 450/4-92-008a, "Users Guide for the Industrial Source Complex (ISC2) Dispersion Models", Vol. 1, Section 3.3.1). Figures D.4-1 and D.4-2 illustrate the breakdown of individual sources into squares for both the current and future scenarios, respectively. It is important to note that all Waste Pits, except for Waste Pit 3, required one square to approximate the actual square area. Because of its size and irregular shape, Waste Pit 3 required five individual squares to approximate its actual square area.

ISCLT2 requires the user to input the coordinates of the southwest corner of individual squares along with the length of one side, assuming a box with four equal sides (U.S. EPA Publication 450/4-92-008a, "Users Guide for the Industrial Source Complex (ISC2) Dispersion Models", Vol. 1, Section 3.3.1). Tables D.4-4 and D.4-5 show the X and Y coordinates and length of each source considered in both the current and future scenarios.

Emission Rates

With the exception of Waste Pits 1 and 2 in the future scenario, all other Waste Pits were assumed to have a unit emission rate of 0.1 g/m²s. Waste Pits 1 and 2 in the future scenario have a unit emission rate of 0.05 g/m²s in order to account for vegetative cover during 6 months of the year. The selection of 0.1 g/m²s over standard unit emission rate of 1.0 g/m²s was decided after observing the model results. ISCLT2 print limits concentration results to 1 x 10⁶ order of magnitude. Using an unit emission rate of 1.0 g/m²s, in some cases, produced concentration results on the order of 1 X 10⁷ which is larger than the allowable field.

Receptor Data

A receptor is defined as a user-selected point at a given distance from a source or origin. ISCLT2 estimates the location of maximum on-site and off-site ground level concentrations at receptors from sources (U.S. EPA Publication 450/4-92-008a, "Users Guide for the Industrial Source Complex (ISC2) Dispersion Models", Vol. 1, Section 1.2.2). On-site and off-site receptors were determined by the fence line surrounding the FEMP facility. A series of receptors around a source is commonly referred to as a "receptor grid" and may be expressed in polar or Cartesian coordinates (U.S. EPA Publication 450/4-92-008a, "Users Guide for the Industrial Source Complex (ISC2) Dispersion Models", Vol. 1, Section 3.4.1.1). For the purpose of Operable Unit 1 air dispersion modeling, two Cartesian coordinate receptor grids were used, a coarse and a fine mesh grid. The coarse grid consisted of a 494 receptors spaced 250 meters apart (see Figure D.4-4). The fine mesh grid was centered over the maximum concentration coarse grid receptors and were spaced 50 meters apart.

From the ISCLT2 calculations using the coarse grid as input, maximum on-site and off-site ground level concentrations were determined. A fine mesh grid was centered near these maximum concentrations and the ISCLT2 was rerun. (see Figures D.4-4 and D.4-5). A receptor is located at each point where two lines intersect to form the graph. The fine mesh grid increased the accuracy of estimating maximum ground level concentrations.

Discrete receptors were also used in the modeling to account for concentrations at sensitive locations. Discrete receptors consisted of four elementary schools, one high school and one day nursery. The six discrete receptors, location and Cartesian coordinates from the origin are listed in Table D.4-6.

Breakdown of Air Dispersion Model Runs

A total of 36 ISCLT2 model runs were executed utilizing a combinations of the current and future emission scenarios, coarse and fine grids, on-site and off-site receptors and 6 years of meteorological data. A breakdown of model runs are listed below:

Current Scenario

- (1 run/yr using coarse grid to calc on/off-site conc.) x (6 yrs met data) = 6 runs
- (1 run/yr using fine grid to calc on-site conc.) x (6 yrs met data) = 6 runs
- (1 run/yr using fine grid to calc off-site conc.) x (6 yrs met data) = 6 runs

This represent a total of 18 model runs for the current scenario.

Future Scenario

- (1 run/yr using coarse grid to calc on/off-site conc.) x (6 yrs met data) = 6 runs
- (1 run/yr using refined grid to calc on-site conc.) x (6 yrs met data) = 6 runs
- (1 run/yr using refined grid to calc off-site conc.) x (6 yrs met data) = 6 runs

This represents a total of 18 model runs for the future scenario

Results of Air Dispersion Modeling

This sections summarizes the results from ISCLT2 unit emission rate modeling of Operable Unit 1, using the input parameters and methodology mentioned above. All concentrations and locations were based on the fine mesh receptor grid for on-site and off-site receptors in the current and future scenarios. It is important to note that maximum ground level concentrations from individual sources do not always occur at the same receptor location as from combined sources. The concentration impact at a receptor is greatly influenced by the distance between the source and the receptor.

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Current scenario

Table D.4-7 summarizes maximum unit emission rate ground level concentrations at on-site receptors for both individual and combined sources. From 1987 through 1992, the ISCLT2 model consistently calculated maximum concentration, from combined sources, to occur 50 meters south of the origin.

Table D.4-8 shows ISCLT2 unit emission rate modeling results for maximum ground level concentrations at off-site receptors for combined and individual sources. These results estimate the maximum concentration, from combined sources, to occur at the FEMP fenceline at X,Y coordinate (-450 m,-150 m).

It is common that longterm maximum concentrations occur downwind from a source along the prevailing wind direction. This would result in the maximum off-site concentrations occurring northeast of Operable Unit 1, yet ISCLT2 model results contradict this. One explanation is the proximity of the nearest off-site receptor relative to the Waste Pit area, regardless of prevailing wind. Dispersion algorithms used in ISCLT2 model calculate concentrations inversely proportional to distance from a source (U.S. EPA Publication 450/4-92-008b, "Users Guide for the Industrial Source Complex Dispersion Model", Vol. 2, Description of Model Algorithms, Section 1.2.3). Therefore, the closest receptor to a source would yield a higher concentration than a receptor along the prevailing wind direction at a greater distance. The ISCLT2 modeling results for Operable Unit 1 show the distance between source and the nearest off site receptors, downwind in the prevailing wind direction, are more than twice the distance between the source and the nearest off-site receptor not along the prevailing wind direction.

Table D.4-9 shows ISCLT2 model results for maximum ground level concentration at discrete receptors from combined sources in current scenario.

Future scenario

Table D.4-10 summarizes maximum ground level concentrations at on-site receptors for individual and combined sources. Results show that for all 6 years, with the exception of 1987, that the maximum concentrations occurred 50 meters north of the origin. This differs from values calculated in the current scenario by 100 meters because of emission contributions from Waste Pits 5 and 6 that were not considered as emission sources in the current scenario.

Table D.4-11 shows concentration results for off site receptors similar to the those discussed in the current scenario. However, higher concentration values due to added emission sources were the only obvious difference. Table D.4-12 summarizes concentration estimates at discrete receptors.

An example output data file for the ISCLT2 model is listed in Attachment D.III.

0223

TABLE D.4-1

DISPERSION OPTIONS USED IN ISCLT MODELING
 OF OPERABLE UNIT 1

Source Type	Area
Dispersion Mode	Rural
Calculation Mode	Concentration
Building Downwash	None
Flagpole Receptors	None
Discrete Receptors	Yes
Gravitational Settling	None
Variable Emissions	None
Receptor Grid	Cartesian
Discrete Receptor Grid	Cartesian
Meteorology Input	Annual STAR Summaries*

*Individual annual on site data for 1987 through 1992 inclusive.

0224

TABLE D.4-2 -

MIXING HEIGHTS IN METERS USED IN ISCLT MODELING

Year	Stability Class	Wind Speed Class					
		1	2	3	4	5	6
1987	A	2105	1961	1803	1802	1526	2349
	B	1403	1307	1202	1201	1017	1566
	C	1403	1307	1202	1201	1017	1566
	D	1403	1307	1202	1201	1017	1566
	E	5000	5000	5000	5000	5000	5000
	F	5000	5000	5000	5000	5000	5000
1988	A	2133	2351	2030	1812	1665	3255
	B	1422	1567	1353	1208	1110	2170
	C	1422	1567	1353	1208	1110	2170
	D	1422	1567	1353	1208	1110	2170
	E	5000	5000	5000	5000	5000	5000
	F	500	000	5000	5000	5000	5000
1989	A	1854	1995	1698	1524	1730	2313
	B	1236	1330	1132	1016	1153	1542
	C	1236	1330	1132	1016	1153	1542
	D	1236	1330	1132	1016	1153	1542
	E	5000	5000	5000	5000	5000	5000
	F	5000	5000	5000	5000	5000	5000
1990	A	1823	1991	1791	1695	1629	2313
	B	1215	1327	1194	1130	1086	1542
	C	1215	1327	1194	1130	1086	1542
	D	1215	1327	1194	1130	1086	1542
	E	1215	1327	1194	1130	1086	1542
	F	5000	5000	5000	5000	5000	5000
1991	A	1823	1991	1791	1695	1629	2313
	B	1215	1327	1194	1130	1086	1542

0225

TABLE D.4-2
(Continued)

Year	Stability Class	Wind Speed Class					
		1	2	3	4	5	6
1992	C	1215	1327	1194	1130	1086	1542
	D	1215	1327	1194	1130	1086	1542
	E	5000	5000	5000	5000	5000	5000
	F	5000	5000	5000	5000	5000	5000
	A	1823	1991	1791	1695	1629	2313
	B	1215	1327	1194	1130	1086	1542
	C	1215	1327	1194	1130	1086	1542
	D	1215	1327	1194	1130	1086	1542
	E	5000	5000	5000	5000	5000	5000
	F	5000	5000	5000	5000	5000	5000

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TABLE D.4-3

MIXING HEIGHTS IN METERS USED IN ISCLT MODELING

Year	Stability Class					
	A	B	C	D	E	F
1987	290	290	290	284	278	278
1988	291	291	291	284	279	279
1989	290	290	290	284	280	280
1990	290	290	290	285	279	279
1991	292	292	292	286	281	281
1992	290	290	290	284	279	279

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TABLE D.4-4

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SOURCES AND CORRESPONDING X AND Y COORDINATES
FOR OPERABLE UNIT 1 WASTE PIT AREA
CURRENT SCENARIO

Source	X-Coordinate ^a	Y-Coordinate ^a	Length (meters)
OU1 PIT 1	-145	-165	73
OU1 PIT 2	-69	-104	57
OU1 P3SQ1 ^b	-145	0	67
OU1 P3SQ2 ^b	-78	0	61
OU1 P3SQ3 ^b	-222	-103	77
OU1 P3SQ4 ^b	-145	-65	67
OU1 P3SQ5 ^b	-78	-40	44
OU1 PIT 4	25	-45	82
OU1 BURN PIT	-17	-20	43

^aValues are based on a Cartesian coordinate system with origin centered at the Burn Pit.

^bIndividual sources within Waste Pit 3.

0228

TABLE D.4-5

SOURCES AND CORRESPONDING X AND Y COORDINATES
FOR OPERABLE UNIT 1 WASTE PIT AREA
FUTURE SCENARIO

Source	X-Coordinate ^a	Y-Coordinate ^a	LENGTH (meters)
OU1 PIT 1	-145	-165	73
OU1 PIT 2	-69	-104	57
OU1 P3SQ1 ^b	-145	0	67
OU1 P3SQ2 ^b	-78	0	61
OU1 P3SQ3 ^b	-222	-103	77
OU1 P3SQ4 ^b	-145	-65	67
OU1 P3SQ5 ^b	-78	-40	44
OU1 PIT 4	25	-45	82
OU1 PIT 5	-22	70	82
OU1 PIT 6	116	30	38
OU1 BURN PIT	-17	-20	43

^aValues are based on a Cartesian coordinate system with origin centered at the Burn Pit.

^bIndividual sources within Waste Pit 3.

0229

TABLE D.4-6

DISCRETE RECEPTORS AND DISTANCE FOR ORIGIN

Discrete Receptors	X-Coordinate (meters)	Y-Coordinate (meters)
Crosby Elementary	-1825	-2865
Morgan Elementary	-3460	3870
Elda Elementary	4722	1960
St. John Elementary	6470	-4590
Ross Middle/High School	5500	3460
Ross County Day Nursery	5000	2390

0230

TABLE D.4-7

MAXIMUM CONCENTRATIONS* (UNIT EMISSION RATES) AND CORRESPONDING LOCATIONS^b
FOR CURRENT SCENARIO WITH ACCESS CONTROLS (ON SITE) AND WITHOUT ACCESS
CONTROLS USING 50 METER RECEPTOR SPACING

	1987	1988	1989	1990	1991	1992
Pit 1	163625.0 (-50,-100)	198051.0 (-50,-100)	209170.1 (-50,-100)	192490.8 (-50,-100)	171553.7 (-50,-100)	174955.0 (-50,-100)
Pit 2	139991.0 (0,-50)	167425.0 (0,-50)	175927.6 (0,-50)	162517.6 (0,-50)	146546.0 (0,-50)	148492.0 (0,-50)
Pit 3SQ1	151107.8 (-50,50)	182899.0 (-50,50)	193591.0 (-50,50)	176968.0 (-50,50)	157741.0 (-50,50)	160758.9 (-50,50)
Pit 3SQ2	168505.0 (0,50)	203998.0 (0,50)	215484.3 (0,50)	197993.7 (0,50)	176842.0 (0,50)	180078.4 (0,50)
Pit 3SQ3	146008.0 (-100,-50)	172583.0 (-100,-50)	184113.0 (-100,-50)	169876.7 (-100,-50)	152749.0 (-100,-50)	155766.9 (-100,-50)
Pit 3SQ4	140161.0 (-50,0)	169333.6 (-50,0)	178851.6 (-50,0)	164475.0 (-50,0)	146641.0 (-50,0)	149362.0 (-50,0)
Pit 3SQ5	104583.0 (0,0)	124255.9 (0,0)	132097.6 (0,0)	120980.7 (0,0)	108747.0 (0,0)	110191.9 (0,0)
Pit 3	397713.0 (0,0)	462925.0 (0,50)	492634.4 (0,0)	453022.7 (0,0)	410448.9 (0,0)	417316.2 (0,0)

TABLE D.4-7
(Continued)

	1987	1988	1989	1990	1991 ^a	1992
Pit 4	148834.7	173306.9	186910.9	169282.7	151755.0	154008.4
	(150,0)	(150,0)	(150,0)	(150,0)	(150,0)	(150,0)
Burn Pit	128679.0	149802.9	161431.6	146445.0	132054.0	133880.0
	(50,0)	(50,0)	(50,0)	(50,0)	(50,0)	(50,0)
All Pits ^c	625257.0	674888.0	716371.8	669423.0	618112.0	641847.8
	(0,-50)	(0,-50)	(0,-50)	(0,-50)	(0,-50)	(0,-50)

^aUnits are in micrograms per cubic meter ($\mu\text{g}/\text{m}^3$).

^bUnits are in meters with origin being the center of Burn Pit.

^cInclude pits 1 through 4 and the Burn Pit.

D-4-22

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TABLE D.4-8

**MAXIMUM OFF-SITE CONCENTRATIONS* (UNIT EMISSION RATES) AND CORRESPONDING LOCATIONS^b
CURRENT SCENARIO WITH ACCESS CONTROLS USING 50 METER RECEPTOR SPACING**

	1987	1988	1989	1990	1991	1992
Pit 1	10228.31 (-450,-150)	7489.102 (-450,-150)	7063.234 (-450,-250)	7165.182 (-450,-150)	6363.6 (-450,-150)	7397.62 (-450,-250)
Pit 2	4798.576 (-450,-250)	3359.372 (-450,-250)	3371.88 (-450,-250)	3131.748 (-450,-150)	2916.144 (-450,-250)	3554.92 (-450,-250)
Pit 3SQ1	7039.853 (-500,-100)	5151.677 (-500,0)	5016.453 (-450,-150)	4939.029 (-500,0)	4367.869 (-500,0)	5216.973 (-450,-150)
Pit 3SQ2	5328.616 (-450,-150)	3742.01 (-450,-150)	3773.754 (-450,-150)	3427.44 (-450,-150)	3248.213 (-450,-150)	3965.685 (-450,-150)
Pit 3SQ3	15708.48 (-450,-150)	11283.29 (-450,-150)	11107.47 (-450,-150)	10533.64 (-450,-150)	9843.991 (-450,-150)	11576.44 (-450,-150)
Pit 3SQ4	8756.585 (-450,-150)	6218.983 (-450,-150)	6136.477 (-450,-150)	5783.537 (-450,-150)	5406.881 (-450,-150)	6435.51 (-450,-150)
Pit 3SQ5	3138.644 (-450,-150)	2198.492 (-450,-150)	2151.244 (-450,-150)	2048.952 (-450,-150)	1908.552 (-450,-150)	2281.08 (-450,-150)
Pit 3	39804.79 (-450,-150)	28320.95 (-450,-150)	28185.4 (-450,-150)	26222.21 (-450,-150)	24665.60 (-450,-150)	29475.69 (-450,-150)

TABLE D.4-8
(Continued)

	1987	1988	1989	1990	1991	1992
Pit 4	6522.06	4527.398	4551.336	4787.007	4175.914	4776.39
	(-450,-200)	(450,650)	(-450,-200)	(450,650)	(450,650)	(-450,-200)
Burn Pit	2351.45	1640.655	1600.702	1528.508	1415.971	1701.311
	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)
All Pits ^a	63205.07	45184.13	44084.2	42228.38	39037.52	46063.09
	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)

^aUnits are in micrograms per cubic meter (ug/m³).

^bUnits are in meters with origin being the center of Burn Pit.

^cInclude pits 1 through 4 and Burn Pit.

D-4-24

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TABLE D.4-9

CONCENTRATIONS* (UNIT EMISSION RATES) AT DISCRETE RECEPTORS FROM ALL^b
OPERABLE UNIT 1 SOURCES RELEVANT TO CURRENT SCENARIO

	1987	1988	1989	1990	1991	1992
Crosby Elementary School	864.88	752.53	853.41	665.44	633.21	795.76
Morgan Elementary School	364.01	361.22	323.88	304.91	273.11	403.16
Elda Elementary School	1498.77	1754.32	1889.81	1634.67	1388.15	1345.54
Saint Johns Elementary School	556.52	618.36	686.13	684.56	628.52	646.01
Ross High School	1015.63	1188.15	1269.33	1145.20	961.42	968.27
Ross County Daycare Nursery	1303.98	1525.45	1638.59	1438.12	1216.17	1190.91

*Units are in micrograms per cubic meter (ug/m³).

^bInclude pits 1 through 4 and the Burn Pit.

D-4-25

TABLE D.4-10

MAXIMUM CONCENTRATIONS^a (UNIT EMISSION RATES) AND CORRESPONDING LOCATIONS^b FOR FUTURE
SCENARIO WITH ACCESS CONTROLS (ON SITE) AND WITHOUT ACCESS CONTROLS USING
50 METER RECEPTOR SPACING

	1987	1988	1989	1990	1991	1992
Pit 1	81812.0 (-50,-100)	99025.0 (-50,-100)	104585.0 (-50,-100)	96245.6 (-50,-100)	85777.0 (-50,-100)	87477.7 (-50,-100)
Pit 2	69995.0 (0,-50)	83712.0 (0,-50)	87963.8 (0,-50)	81258.8 (0,-50)	73273.0 (0,-50)	74246.0 (0,-50)
Pit 3SQ1	151107.8 (-50,50)	182899.0 (-50,50)	193591.0 (-50,50)	176968.0 (-50,50)	157741.0 (-50,50)	160758.8 (-50,50)
Pit 3SQ2	168505.0 (0,50)	203998.0 (0,50)	215484.0 (0,50)	197995.9 (0,50)	176844.0 (0,50)	180080.0 (0,50)
Pit 3SQ3	146008.0 (-100,-50)	172583.3 (-100,-50)	184113.0 (-100,-50)	169876.8 (-100,-50)	152749.0 (-100,-50)	155767.0 (-100,-50)
Pit 3SQ4	140161.0 (-50,0)	169333.6 (-50,0)	178851.6 (-50,0)	164475.0 (-50,0)	146641.0 (-50,0)	149362.5 (-50,0)
Pit 3SQ5	104583.0 (0,0)	124255.9 (0,0)	132097.6 (0,0)	120980.7 (0,0)	108747.5 (0,0)	110191.9 (0,0)
Pit 3	397713.0 (0,0)	462925.0 (0,50)	492634.0 (0,0)	453022.6 (0,0)	410448.8 (0,0)	417316.0 (0,0)

D-4-26

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TABLE D.4-10
(CONTINUED)

	1987	1988	1989	1990	1991	1992
Pit 4	148834.7 (150,0)	173306.9 (150,0)	186910.9 (150,0)	169282.7 (150,0)	151755.0 (150,0)	154008.4 (150,0)
Pit 5	148877.5 (100,100)	173162.6 (100,100)	186971.7 (100,100)	170278.0 (100,100)	152910.0 (100,100)	155525.8 (100,100)
Pit 6	80858.6 (100,50)	83318.4 (200,50)	89719.3 (200,50)	79972.0 (200,50)	71824.0 (200,50)	74699.2 (150,100)
Burn Pit	128679.5 (50,0)	149802.9 (50,0)	161431.6 (50,0)	146444.9 (50,0)	132054.5 (50,0)	133879.6 (50,0)
All Pits ^a	608017.1 (0,0)	681441.8 (0,50)	704125.2 (0,50)	672915.3 (0,50)	608235.6 (0,50)	643546.1 (0,50)

^aUnits are in micrograms per cubic meter (ug/m³).

^bUnits are in meters with origin being the center of Burn Pit.

^cInclude pits 1 through 6 and the Burn Pit.

TABLE D.4-11

**MAXIMUM OFF-SITE CONCENTRATIONS* (UNIT EMISSION RATES) AND CORRESPONDING LOCATIONS^b
WITH ACCESS CONTROLS FOR FUTURE SCENARIO USING
50 METER RECEPTOR SPACING**

	1987	1988	1989	1990	1991	1992
Pit 1	5114.157	3744.551	3531.617	3582.591	3181.8	3697.62
	(-450,-150)	(-450,-150)	(-450,-250)	(-450,-150)	(-450,-150)	(-450,-250)
Pit 2	2399.288	1679.686	1685.944	1565.874	1458.072	1777.461
	(-450,-250)	(-450,-250)	(-450,-250)	(-450,-150)	(-450,-250)	(-450,-250)
Pit 3SQ1	7039.853	5151.677	5016.453	4939.029	4367.869	5216.973
	(-500,-100)	(-500,0)	(-450,-150)	(-500,0)	(-500,0)	(-450,-150)
Pit 3SQ2	5328.616	3742.01	3773.754	3427.44	3248.213	3965.685
	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)
Pit 3SQ3	15708.48	11283.29	11107.47	10533.64	9843.991	11576.44
	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)
Pit 3SQ4	8756.585	6218.983	6136.477	5783.537	5406.881	6435.51
	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)
Pit 3SQ5	3138.644	2198.492	2151.244	2048.952	1908.552	2281.08
	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)
Pit 3	39804.79	28320.95	28185.4	26222.21	24665.60	29475.69
	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)	(-450,-150)

D-4-28

TABLE D.4-11
(CONTINUED)

	1987	1988	1989	1990	1991	1992
Pit 4	6522.06 (-450,-200)	4527.398 (450,650)	4551.336 (-450,-200)	4787.007 (450,650)	4175.914 (450,650)	4776.39 (-450,-200)
Pit 5	6505.80 (-500,-100)	6334.917 (550,650)	6643.737 (550,650)	6422.336 (550,650)	5471.16 (550,650)	5744.185 (500,650)
Pit 6	1211.548 (-450,-200)	1209.564 (450,650)	1209.577 (500,650)	1292.174 (450,650)	1140.623 (450,650)	1246.275 (450,650)
Burn Pit	2351.45 (-450,-150)	1640.655 (-450,-150)	1600.702 (-450,-150)	1528.508 (-450,-150)	1415.971 (-450,-150)	1701.311 (-450,-150)
All Pits ^a	62641.3 (-450,-150)	44609.8 (-450,-150)	44006.4 (-450,-150)	41440.8 (-450,-150)	38584.0 (-450,-150)	46003.6 (-450,-150)

^aUnits are in micrograms per cubic meter (ug/m³).

^bUnits are in meters with origin being the center of Burn Pit.

^cInclude pits 1 through 6 and the Burn Pit.

TABLE D.4-12

CONCENTRATIONS^a (UNIT EMISSION RATES) AT DISCRETE RECEPTORS FROM ALL^b
OPERABLE UNIT 1 SOURCES RELEVANT TO FUTURE SCENARIO

	1987	1988	1989	1990	1991	1992
Crosby Elementary School	936.5	814.8	923.7	720.4	685.6	861.5
Morgan Elementary School	402.9	398.5	356.5	335.0	300.4	445.8
Elda Elementary School	1667.0	1951.6	2103.2	1816.2	1543.1	1495.7
Saint Johns Elementary School	612.8	677.9	752.5	752.4	692.6	711.3
Ross High School	1130.1	1322.1	1412.6	1273.7	1069.4	1076.4
Ross County Daycare Nursery	1452.1	1698.7	1825.0	1600.4	1353.7	1324.4

^aUnits are in micrograms per cubic meter (ug/m³).

^bInclude pits 1 through 6 and the Burn Pit.

D-4-30

4782

0240

TABLE D.4-13

COMPARISON OF ISCLT2 MODEL PREDICTIONS
TO AMBIENT RADON MONITORING DATA
FOR THE BASE YEAR 1992

Fernald Monitoring Station ID	Station 1992 Annual Average Concentration (pCi/m ³)*	ISCLT2 Model Prediction (pCi/m ³)**	Ratio of Model to Monitoring Data
AMS 1	0	0.481	--
AMS 2	0	0.224	--
AMS 4	0	0.162	--
AMS 6	0	1.02	--
AMS 7	1,100	0.217	1.45×10^{-4}
AMS 8	100	0.316	6.32×10^{-4}
AMS 9	200	0.491	8.18×10^{-4}
AMS 10	300	0.042	6.00×10^{-5}
AMS 11	100	0.024	4.80×10^{-5}

* These concentrations include the subtraction of the 1992 annual average background concentration of 400 pCi/m³.

** Includes the contribution from all Operable Unit 1 radon sources.

D-4-32

4282

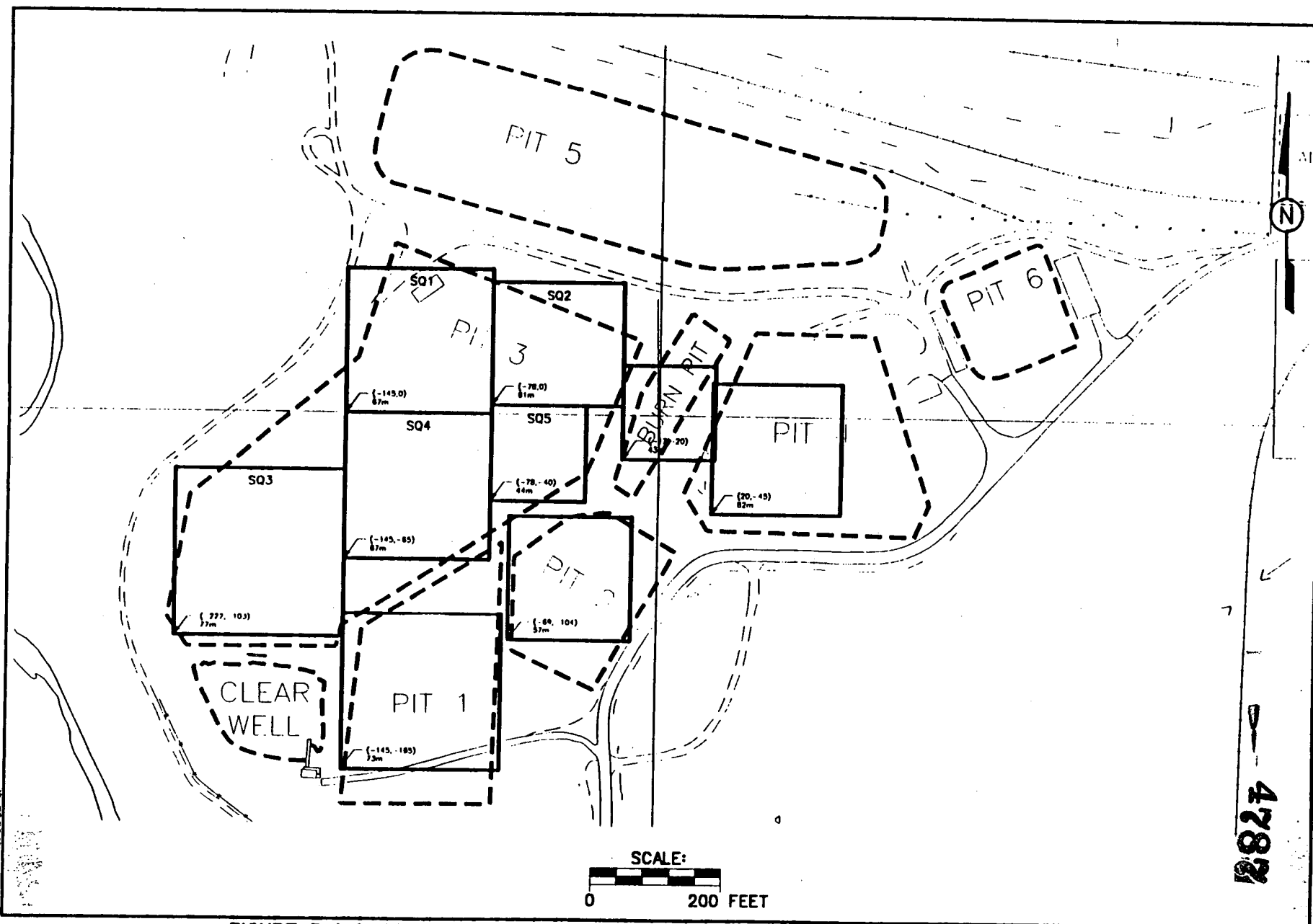


FIGURE D.4-1. OPERABLE UNIT 1 SOURCES FOR CURRENT SCENARIO FERNALD, OHIO



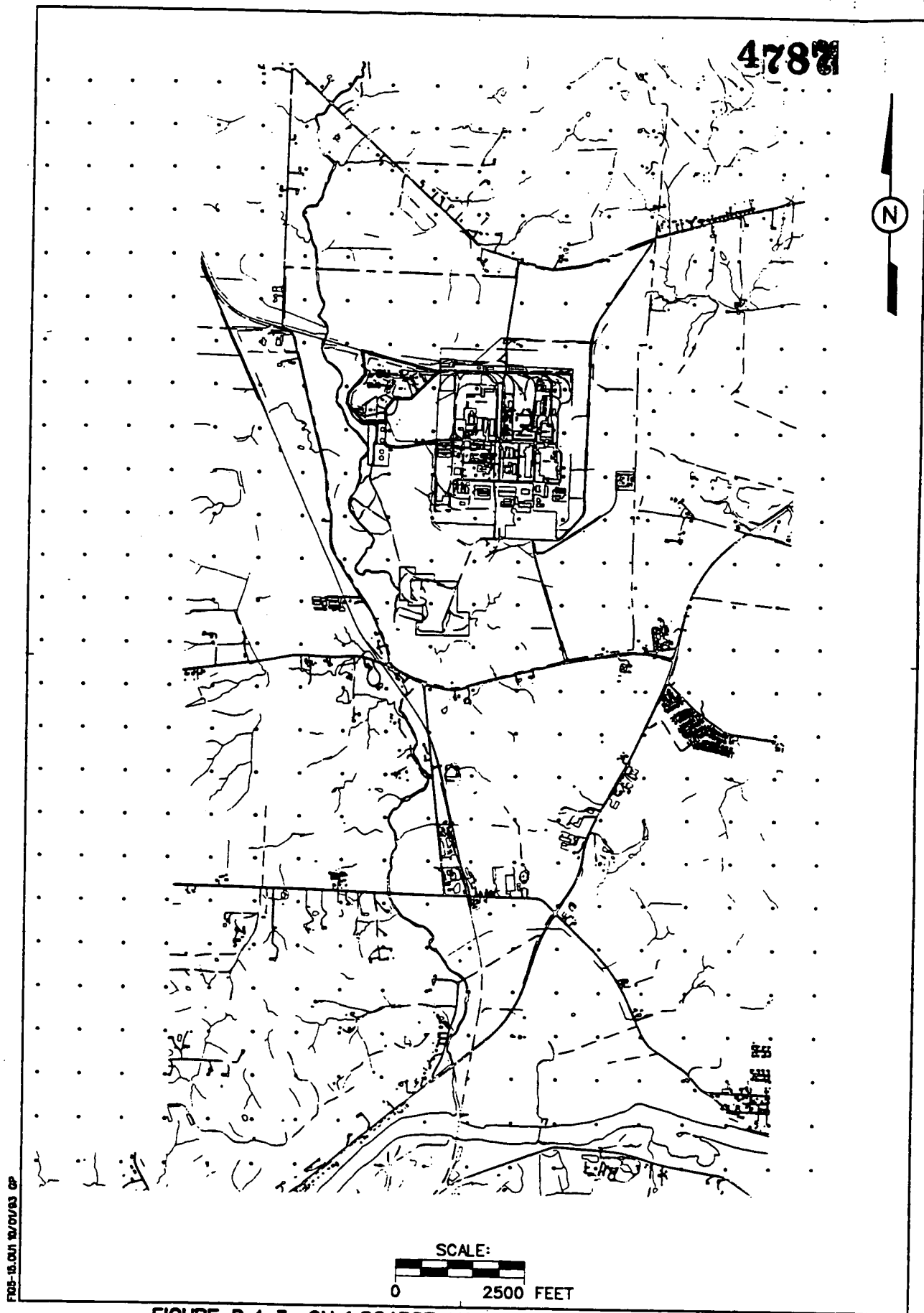


FIGURE D.4-3. OU-1 COARSE MODELING GRID FERNALD, OHIO



FIGURE D.4-4. REFINED GRID FOR ON SITE RECEPTORS FERNALD, OHIO

0245

D-4-35

25 10/10/03 1107-1-0003

D-4-36

00246

NOV 1988



ATTACHMENT D.I
ON-SITE METEOROLOGICAL
DATA STAR SUMMARIES
FOR 1987-1992

1987 METEOROLOGICAL STAR SUMMARY FOR FEMP

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1787

1987 METEOROLOGICAL STAR SUMMARY FOR FEMP (Continued)

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1988 METEOROLOGICAL STAR SUMMARY FOR FEMP

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1989 METEOROLOGICAL STAR SUMMARY FOR FEMP

4782

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0252

4782

989 METEOROLOGICAL STAR SUMMARY FOR FEMP (Continued)

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0253

A7SL

1990 METEOROLOGICAL STAR SUMMARY FOR FEMP

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1991 METEOROLOGICAL STAR SUMMARY FOR FEMP

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4782

4787

1991 METEOROLOGICAL STAR SUMMARY FOR FEMP (Continued)

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0257

1992 METEOROLOGICAL STAR SUMMARY FOR FEMP

4782

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0258

4787

1992 METEOROLOGICAL STAR SUMMARY FOR FEMP (Continued)

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0856

0259

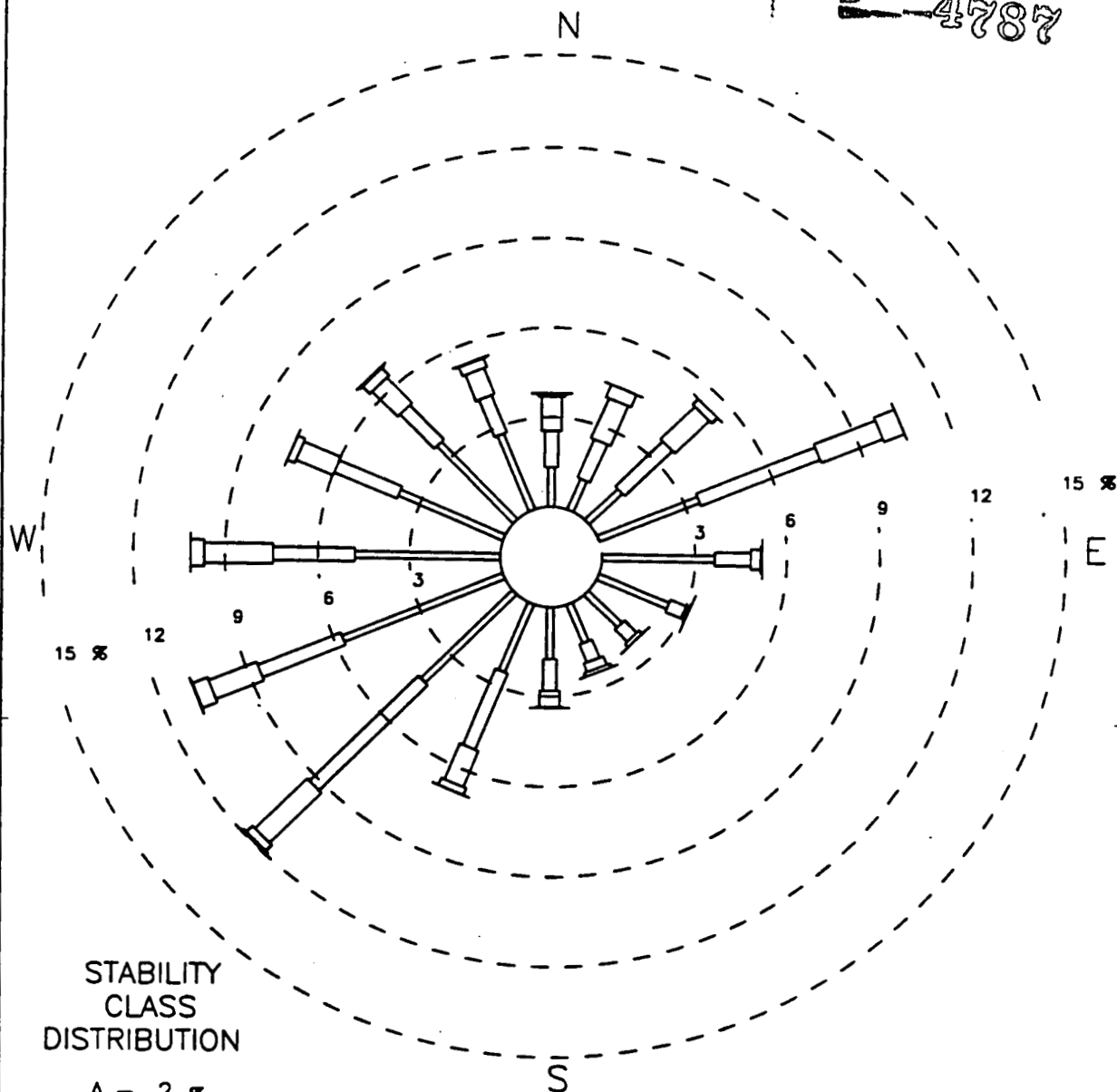
4782

ATTACHMENT D.II
WIND ROSE SUMMARIES
FOR 1987-1992

0260

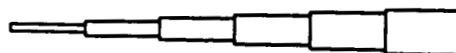
FREQUENCY OF WIND SPEED & DIRECTION

4787



STABILITY CLASS DISTRIBUTION

- A - 2 %
- B - 3 %
- C - 5 %
- D - 38 %
- E - 29 %
- F - 24 %



0-3 4-6 7-10 11-16 17-21 22-99
(45 %) (32 %) (19 %) (4 %) (0 %) (0 %)

WIND SPEED SCALE (KNOTS)

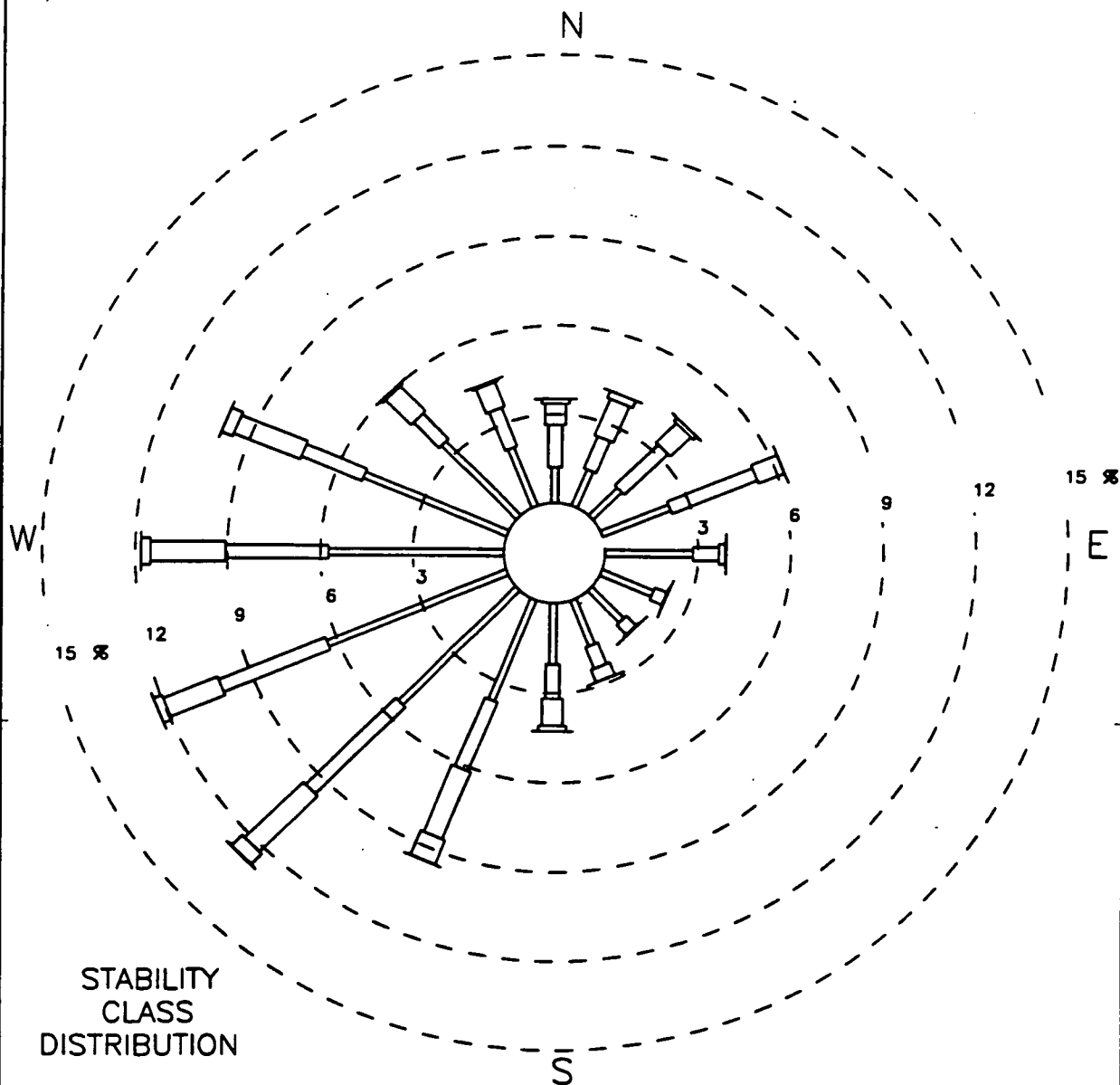
NOTE - WIND DIRECTION IS THE DIRECTION WIND IS BLOWING FROM

0261

FIGURE D-II-1. WIND ROSE FOR THE FEMP SITE YEAR - 1987 FERNALD ENVIRONMENTAL MANAGEMENT PROJECT FERNALD, OHIO

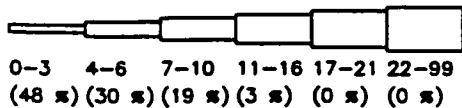
4787

FREQUENCY OF WIND SPEED & DIRECTION



STABILITY CLASS DISTRIBUTION

A - 4 %
 B - 3 %
 C - 5 %
 D - 32 %
 E - 29 %
 F - 27 %



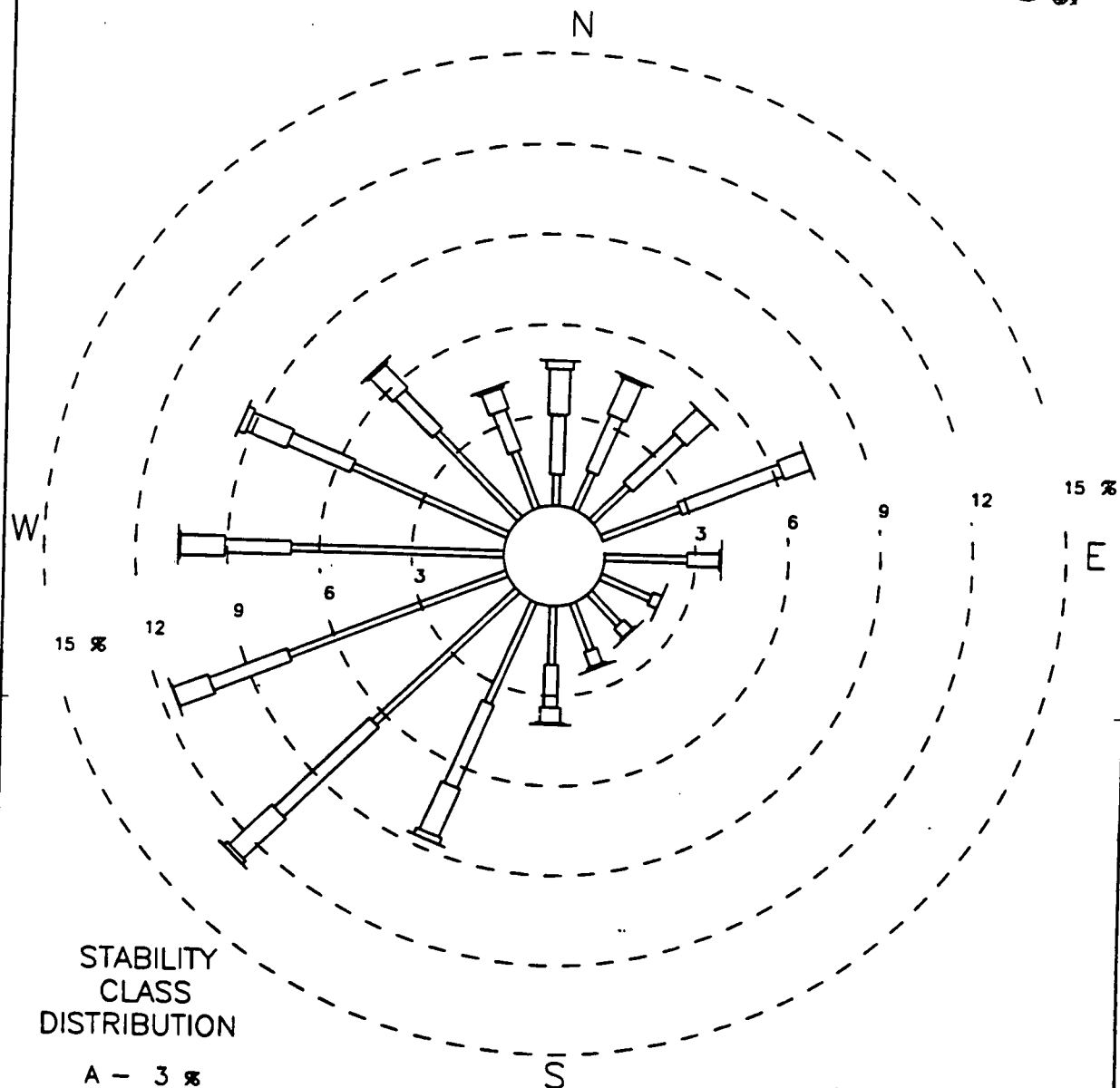
WIND SPEED SCALE (KNOTS)

NOTE - WIND DIRECTION IS THE DIRECTION WIND IS BLOWING FROM

0262

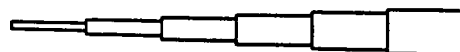
FIGURE D-II-2. WIND ROSE FOR THE FEMP SITE YEAR - 1988 FERNALD ENVIRONMENTAL MANAGEMENT PROJECT FERNALD, OHIO

FREQUENCY OF WIND SPEED & DIRECTION



STABILITY CLASS DISTRIBUTION

- A - 3 %
- B - 3 %
- C - 4 %
- D - 35 %
- E - 30 %
- F - 25 %



0-3 4-6 7-10 11-16 17-21 22-99
(52 %) (31 %) (15 %) (1 %) (0 %) (0 %)

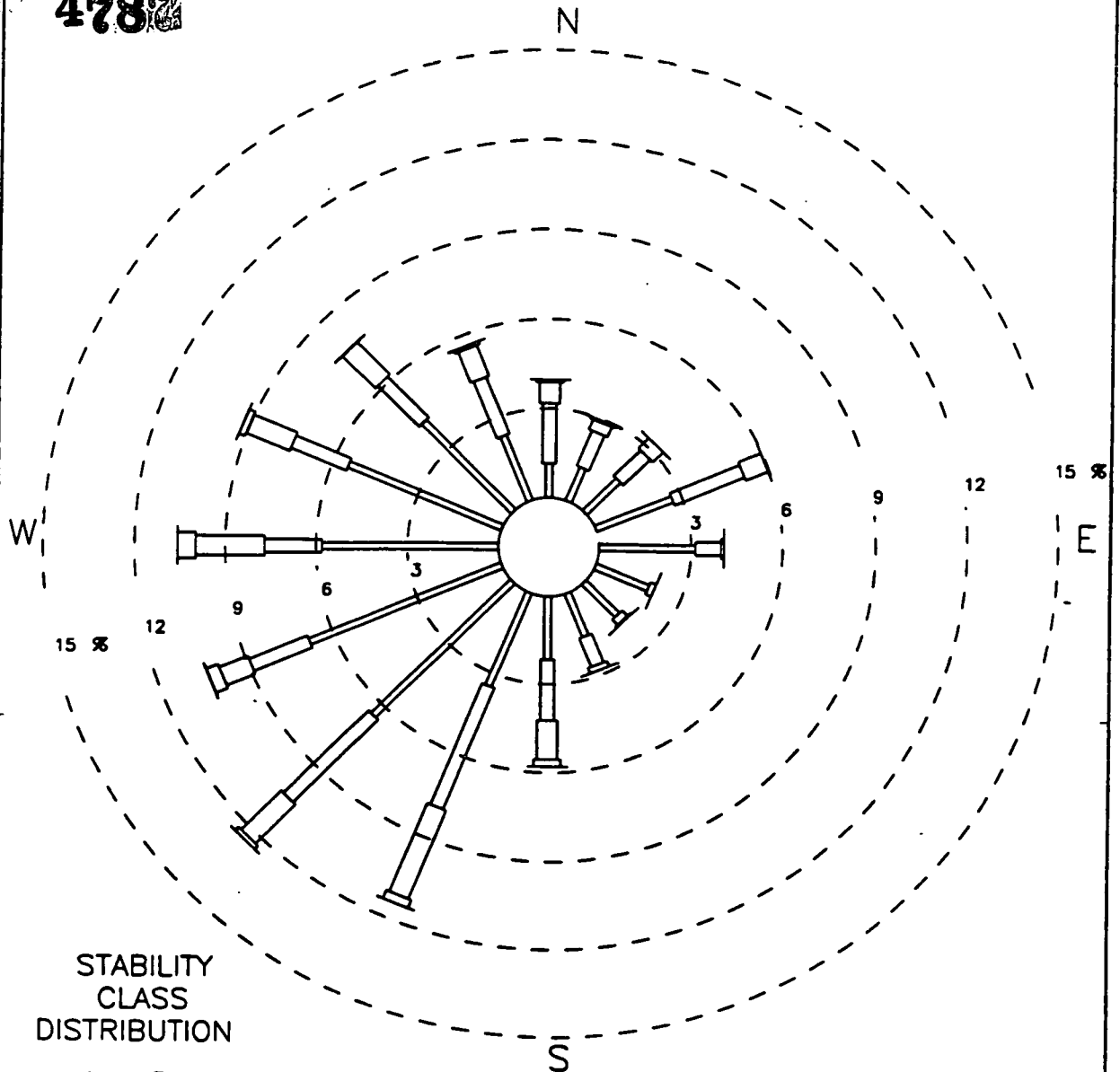
WIND SPEED SCALE (KNOTS)

NOTE - WIND DIRECTION IS THE DIRECTION WIND IS BLOWING FROM

FIGURE D-II-3. WIND ROSE FOR THE FEMP SITE YEAR - 1989 FERNALD ENVIRONMENTAL MANAGEMENT PROJECT FERNALD, OHIO

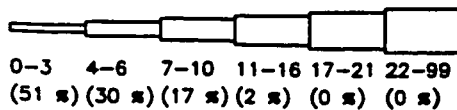
FREQUENCY OF WIND SPEED & DIRECTION

4782



STABILITY CLASS DISTRIBUTION

A - 3 %
B - 2 %
C - 4 %
D - 33 %
E - 37 %
F - 21 %



WIND SPEED SCALE (KNOTS)

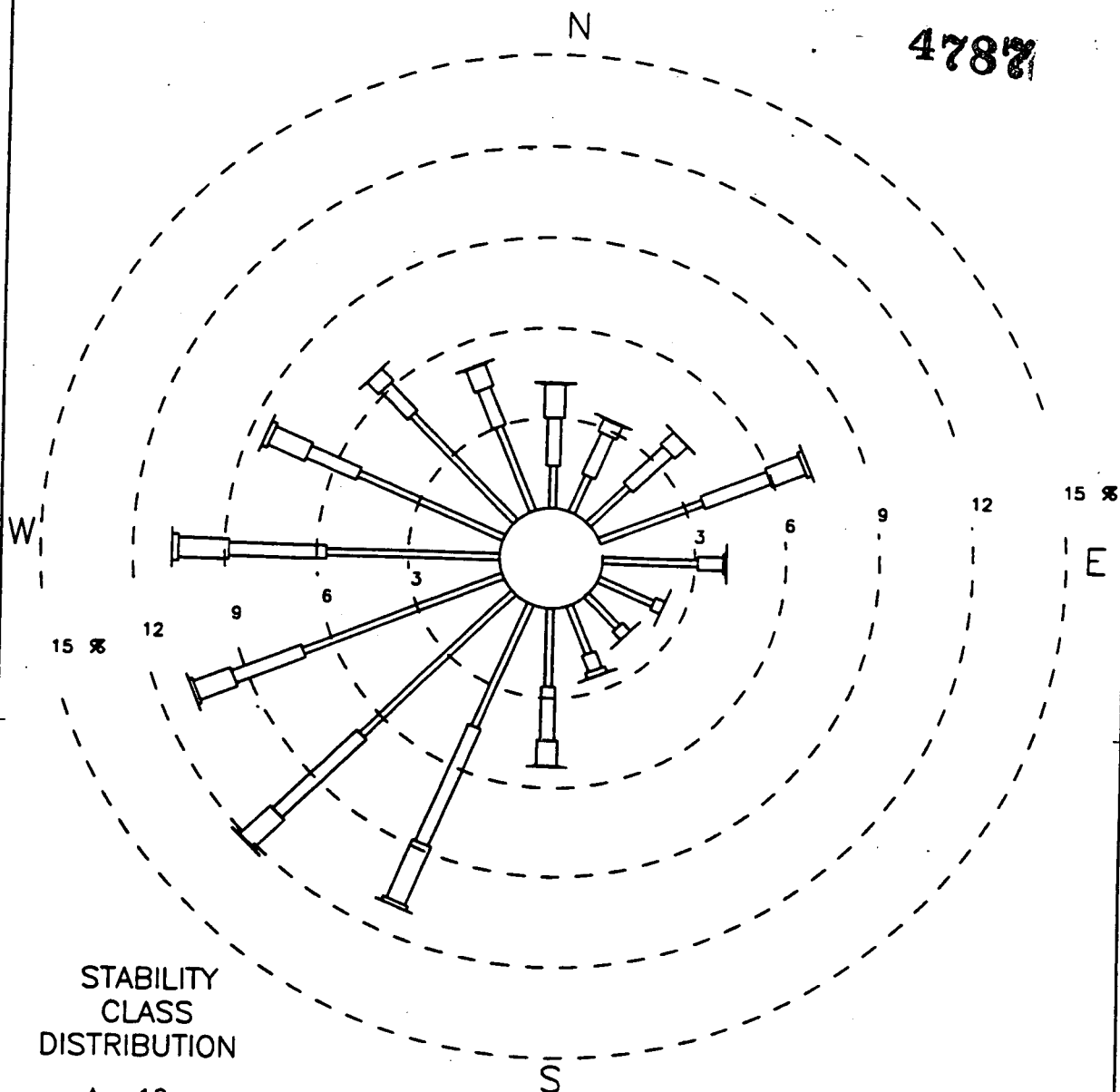
NOTE - WIND DIRECTION IS THE DIRECTION WIND IS BLOWING FROM

0264

FIGURE D-II-4. WIND ROSE FOR THE FEMP SITE YEAR - 1990 FERNALD ENVIRONMENTAL MANAGEMENT PROJECT FERNALD, OHIO

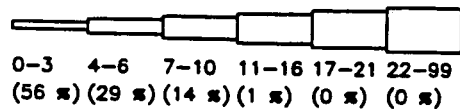
FREQUENCY OF WIND SPEED & DIRECTION

4782



STABILITY CLASS DISTRIBUTION

- A - 19 %
- B - 4 %
- C - 4 %
- D - 28 %
- E - 23 %
- F - 21 %



0-3 4-6 7-10 11-16 17-21 22-99
(56 %) (29 %) (14 %) (1 %) (0 %) (0 %)

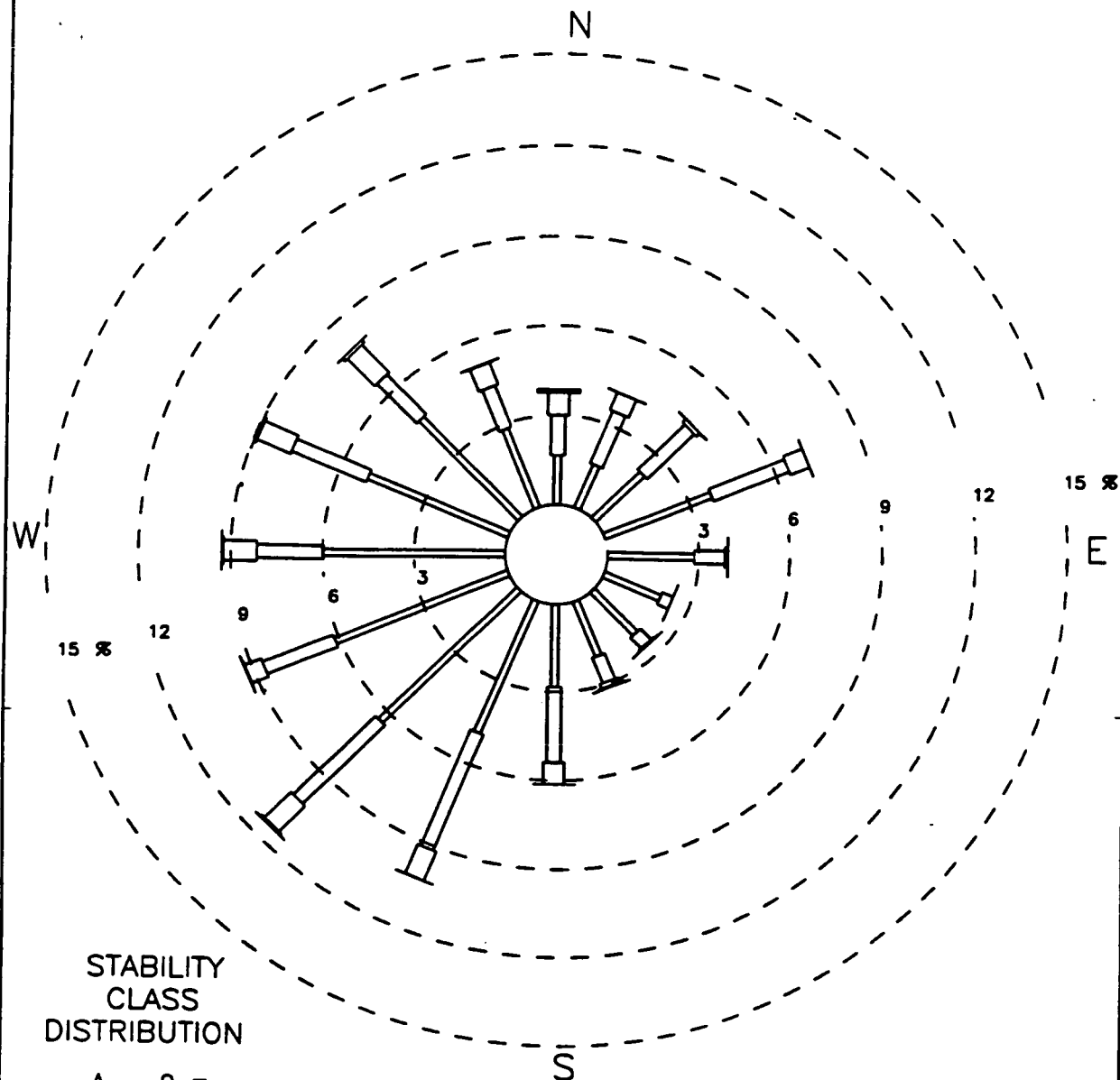
WIND SPEED SCALE (KNOTS)

NOTE - WIND DIRECTION IS THE
DIRECTION WIND IS BLOWING FROM

0265

FIGURE D-II-5. WIND ROSE FOR THE FEMP SITE YEAR - 1991 FERNALD
ENVIRONMENTAL MANAGEMENT PROJECT FERNALD, OHIO

FREQUENCY OF WIND SPEED & DIRECTION



STABILITY CLASS DISTRIBUTION

A	-	9	%
B	-	4	%
C	-	4	%
D	-	33	%
E	-	27	%
F	-	22	%



0-3 4-6 7-10 11-16 17-21 22-99
(57 票) (32 票) (10 票) (0 票) (0 票) (0 票)

WIND SPEED SCALE (KNOTS)

NOTE - WIND DIRECTION IS THE
DIRECTION WIND IS BLOWING FROM

0266

FIGURE D-II-6. WIND ROSE FOR THE FEMP SITE YEAR - 1992 FERNALD ENVIRONMENTAL MANAGEMENT PROJECT FERNALD, OHIO

ATTACHMENT D.III

SAMPLE ISCLT2 MODEL OUTPUT

4782

ISCLT2 - (DATED 93109)

IBM-PC VERSION (2.1) ISCLT2X

(C) COPYRIGHT 1992, TRINITY CONSULTANTS, INC.

SERIAL NUMBER 10295 SOLD TO BROWN & ROOT ENVIRONMENTAL

Run Began on 7/16/1993 at 15:11:18

*** TRINITY SOURCE FILE NAME: C:\MODELS\ISCLT2\OU1CUR.PMT

*** TRINITY RECEPTOR FILE NAME: C:\MODELS\ISCLT2\HONCUR.REC

CO STARTING

CO TITLEONE HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER

CO TITLETWO RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO

CO MODELOPT DFAULT CONC RURAL

CO AVERTIME ANNUAL

CO POLLUTID POLL1

CO TERRHGT5 FLAT

CO ELEVUNIT METERS

CO RUNORNOT RUN

CO FINISHED

SO STARTING

SO LOCATION OU1PIT1 AREA -145.00 -165.00 0.00

SO SRCPARAM OU1PIT1 0.100000 0.00 73.00

SO LOCATION OU1PIT2 AREA -69.00 -104.00 0.00

SO SRCPARAM OU1PIT2 0.100000 0.00 57.00

SO LOCATION OU1P3SQ1 AREA -145.00 0.00 0.00

SO SRCPARAM OU1P3SQ1 0.100000 0.00 67.00

SO LOCATION OU1P3SQ2 AREA -78.00 0.00 0.00

SO SRCPARAM OU1P3SQ2 0.100000 0.00 61.00

SO LOCATION OU1P3SQ3 AREA -222.00 -103.00 0.00

SO SRCPARAM OU1P3SQ3 0.100000 0.00 77.00

SO LOCATION OU1P3SQ4 AREA -145.00 -65.00 0.00

SO SRCPARAM OU1P3SQ4 0.100000 0.00 67.00

SO LOCATION OU1P3SQ5 AREA -78.00 -40.00 0.00

SO SRCPARAM OU1P3SQ5 0.100000 0.00 44.00

SO LOCATION OU1PIT4 AREA 25.00 -45.00 0.00

SO SRCPARAM OU1PIT4 0.100000 0.00 82.00

SO LOCATION OU1BPIT AREA -17.00 -20.00 0.00

SO SRCPARAM OU1BPIT 0.100000 0.00 43.00

SO EMISUNIT 1000000.000000 GRAMS/SEC MICROGRAMS/M**3

SO SRCGROUP SGOU1PT1 OU1PIT1

SO SRCGROUP SGOU1PT2 OU1PIT2

SO SRCGROUP SGOU1PT3 OU1P3SQ1 OU1P3SQ2 OU1P3SQ3 OU1P3SQ4 OU1P3SQ5

SO SRCGROUP SGOU1PT4 OU1PIT4

SO SRCGROUP SGOU1BPT OU1BPIT

SO SRCGROUP SGOU1ALL OU1PIT1 OU1PIT2 OU1P3SQ1 OU1P3SQ2 OU1P3SQ3 OU1P3SQ4

SO SRCGROUP SGOU1ALL OU1P3SQ5 OU1PIT4 OU1BPIT

SO FINISHED

RE STARTING

RE GRIDCART ONSTEGRD STA

RE GRIDCART ONSTEGRD XYINC -500.00 21 50.00 -500.00 21 50.00

RE GRIDCART ONSTEGRD END

RE DISCCART -1825.00 -2865.00

RE DISCCART -3460.00 3870.00

RE DISCCART 4722.00 1960.00

RE DISCCART 6470.00 -4590.00

RE DISCCART 5500.00 3460.00

RE DISCCART 5000.00 2390.00

RE FINISHED

4780

ME STARTING
ME INPUTFIL C:\MODELS\ISCLT2\FEMP87.STR (7X,6F7.6)
ME ANEMHGT 10.000 METERS
ME SURFDATA 00000 1987 FEMP
ME UAIRDATA 00000 1900 DAYTON
ME AVESPEED 1.50 2.50 4.30 6.80 9.50 12.50
ME AVETEMPS ANNUAL 290.00 290.00 290.00 284.00 278.00 278.00
ME AVEMIXHT ANNUAL A 2105.00 1961.00 1803.00 1802.00 1526.00 2349.00
ME AVEMIXHT ANNUAL B 1403.00 1307.00 1202.00 1201.00 1017.00 1566.00
ME AVEMIXHT ANNUAL C 1403.00 1307.00 1202.00 1201.00 1017.00 1566.00
ME AVEMIXHT ANNUAL D 1403.00 1307.00 1202.00 1201.00 1017.00 1566.00
ME AVEMIXHT ANNUAL E 5000.00 5000.00 5000.00 5000.00 5000.00 5000.00
ME AVEMIXHT ANNUAL F 5000.00 5000.00 5000.00 5000.00 5000.00 5000.00
ME FINISHED
OU STARTING
OU RECTABLE INDSRC SRCGRP
OU MAXTABLE 10 INDSRC SRCGRP SOCONT
OU PLOTFILE ANNUAL SGOU1PT1 C:\MODELS\ISCLT32\HONCUR87.GPH 70
OU PLOTFILE ANNUAL SGOU1PT2 C:\MODELS\ISCLT32\HONCUR87.GPH 70
OU PLOTFILE ANNUAL SGOU1PT3 C:\MODELS\ISCLT32\HONCUR87.GPH 70
OU PLOTFILE ANNUAL SGOU1PT4 C:\MODELS\ISCLT32\HONCUR87.GPH 70
OU PLOTFILE ANNUAL SGOU1BPT C:\MODELS\ISCLT32\HONCUR87.GPH 70
OU PLOTFILE ANNUAL SGOU1ALL C:\MODELS\ISCLT32\HONCUR87.GPH 70
OU FINISHED

*** SETUP Finishes Successfully ***

0269

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 1

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** MODEL SETUP OPTIONS SUMMARY ***

**Model Is Setup For Calculation of Average CONCentration Values.

**Model Uses RURAL Dispersion.

**Model Uses Regulatory DEFAULT Options:

1. Final Plume Rise.
2. Stack-tip Downwash.
3. Buoyancy-induced Dispersion.
4. Default Wind Profile Exponents.
5. Default Vertical Potential Temperature Gradients.
6. "Upper Bound" Values For Supersquat Buildings.
7. No Exponential Decay for RURAL Mode

**Model Assumes Receptors on FLAT Terrain.

**Model Assumes No FLAGPOLE Receptor Heights.

**Model Calculates 1 STAR Average(s) for the Following Months: 0 0 0 0 0 0 0 0 0 0 0 0
Seasons/Quarters: 0 0 0 0
and Annual: 1

**Model Assumes 1 STAR Summaries In Data File for the Averaging Periods Identified Above

**This Run Includes: 9 Source(s); 6 Source Group(s); and 447 Receptor(s)

**The Model Assumes A Pollutant Type of: POLL1

**Model Set To Continue RUNNING After the Setup Testing.

**Output Options Selected:

Model Outputs Tables of Long Term Values by Receptor (RECTABLE Keyword)
Model Outputs Tables of Maximum Long Term Values (MAXTABLE Keyword)
Model Outputs External File(s) of Long Term Values for Plotting (PLOTFILE Keyword)

**Misc. Inputs: Anem. Hgt. (m) = 10.00 ; Decay Coef. = 0.0000 ; Rot. Angle = 0.0
Emission Units = GRAMS/SEC ; Emission Rate Unit Factor = 0.10000E+07
Output Units = MICROGRAMS/M**3

**Input Runstream File: C:\MODELS\ISCLT32\HONCUR87.DAT

; **Output Print File: C:\MODELS\ISCLT32\HONCUR87.LST

4782

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

** MODELING OPTIONS USED: CONC RURAL FLAT DEFAULT

PAGE 2

*** AREA SOURCE DATA ***

SOURCE	NUMBER	EMISSION RATE	COORD (SW CORNER)		BASE	RELEASE	WIDTH	EMISSION RATE
ID	PART. (USER UNITS		X	Y	ELEV.	HEIGHT	OF AREA	SCALAR VARY
	CATS.	/METER**2)	(METERS)	(METERS)	(METERS)	(METERS)	(METERS)	BY
OU1P1T1	0	0.10000E+00	-145.0	-165.0	0.0	0.00	73.00	
OU1P1T2	0	0.10000E+00	-69.0	-104.0	0.0	0.00	57.00	
OU1P3SQ1	0	0.10000E+00	-145.0	0.0	0.0	0.00	67.00	
OU1P3SQ2	0	0.10000E+00	-78.0	0.0	0.0	0.00	61.00	
OU1P3SQ3	0	0.10000E+00	-222.0	-103.0	0.0	0.00	77.00	
OU1P3SQ4	0	0.10000E+00	-145.0	-65.0	0.0	0.00	67.00	
OU1P3SQ5	0	0.10000E+00	-78.0	-40.0	0.0	0.00	44.00	
OU1P1T4	0	0.10000E+00	25.0	-45.0	0.0	0.00	82.00	
OU1BP1T	0	0.10000E+00	-17.0	-20.0	0.0	0.00	43.00	

0271

4787

*** ISCLT2 - VERSION 93109 ***

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07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

** MODELING OPTIONS USED: CONC

RURAL FLAT

DEFAULT

PAGE 3

*** SOURCE IDs DEFINING SOURCE GROUPS ***

GROUP ID

SOURCE IDs

SGOU1PT1 OU1PIT1 ,

SGOU1PT2 OU1PIT2 ,

SGOU1PT3 OU1P3SQ1, OU1P3SQ2, OU1P3SQ3, OU1P3SQ4, OU1P3SQ5,

SGOU1PT4 OU1PIT4 ,

SGOU1BPT OU1BPIT ,

SGOU1ALL OU1PIT1 , OU1PIT2 , OU1P3SQ1, OU1P3SQ2, OU1P3SQ3, OU1P3SQ4, OU1P3SQ5, OU1PIT4 , OU1BPIT ,

0272

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
 *** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93
 15:11:18
 PAGE 4

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** GRIDDED RECEPTOR NETWORK SUMMARY ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

*** X-COORDINATES OF GRID ***
 (METERS)

-500.0,	-450.0,	-400.0,	-350.0,	-300.0,	-250.0,	-200.0,	-150.0,	-100.0,	-50.0,
0.0,	50.0,	100.0,	150.0,	200.0,	250.0,	300.0,	350.0,	400.0,	450.0,
500.0,									

*** Y-COORDINATES OF GRID ***
 (METERS)

-500.0,	-450.0,	-400.0,	-350.0,	-300.0,	-250.0,	-200.0,	-150.0,	-100.0,	-50.0,
0.0,	50.0,	100.0,	150.0,	200.0,	250.0,	300.0,	350.0,	400.0,	450.0,
500.0,									

0273

4782

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

PAGE 5

*** DISCRETE CARTESIAN RECEPTORS ***

(X-COORD, Y-COORD, ZELEV, ZFLAG)

(METERS)

(-1825.0,	-2865.0,	0.0,	0.0);	(-3460.0,	3870.0,	0.0,	0.0);
(4722.0,	1960.0,	0.0,	0.0);	(6470.0,	-4590.0,	0.0,	0.0);
(5500.0,	3460.0,	0.0,	0.0);	(5000.0,	2390.0,	0.0,	0.0);

0274

4782

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

PAGE 6

* SOURCE-RECEPTOR COMBINATIONS LESS THAN 1.0 METER OR 3*ZLB
IN DISTANCE. CALCULATIONS MAY NOT BE PERFORMED.

SOURCE ID	- - RECEPTOR LOCATION - - XR (METERS) YR (METERS)	DISTANCE (METERS)
OU1PIT1	-100.0 -150.0	-18.07
OU1PIT1	-100.0 -100.0	-11.45
OU1PIT2	-50.0 -100.0	-5.88
OU1PIT2	-50.0 -50.0	-4.95
OU1P3S01	-100.0 0.0	-2.38
OU1P3S01	-100.0 50.0	-17.69
OU1P3S02	-50.0 0.0	-3.81
OU1P3S02	-50.0 50.0	-14.76
OU1P3S03	-200.0 -100.0	-4.30
OU1P3S03	-200.0 -50.0	-21.48
OU1P3S03	-150.0 -50.0	-6.94
OU1P3S04	-100.0 -50.0	-16.02
OU1P3S04	-100.0 0.0	-4.27
OU1P3S05	-50.0 0.0	-5.85
OU1PIT4	50.0 0.0	-29.77
OU1PIT4	100.0 0.0	-12.03
OU1BPIT	0.0 0.0	-19.52

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 7

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** AVERAGE SPEED FOR EACH WIND SPEED CATEGORY ***
(METERS/SEC)

1.50, 2.50, 4.30, 6.80, 9.50, 12.50,

*** WIND PROFILE EXPONENTS ***

STABILITY CATEGORY	WIND SPEED CATEGORY					
	1	2	3	4	5	6
A	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01
B	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01
C	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00
D	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00
E	.35000E+00	.35000E+00	.35000E+00	.35000E+00	.35000E+00	.35000E+00
F	.55000E+00	.55000E+00	.55000E+00	.55000E+00	.55000E+00	.55000E+00

*** VERTICAL POTENTIAL TEMPERATURE GRADIENTS ***
(DEGREES KELVIN PER METER)

STABILITY CATEGORY	WIND SPEED CATEGORY					
	1	2	3	4	5	6
A	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
B	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
C	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
D	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
E	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01
F	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01

*** AVERAGE AMBIENT AIR TEMPERATURE (KELVIN) ***

	STABILITY CATEGORY A	STABILITY CATEGORY B	STABILITY CATEGORY C	STABILITY CATEGORY D	STABILITY CATEGORY E	STABILITY CATEGORY F
ANNUAL	290.0000	290.0000	290.0000	284.0000	278.0000	278.0000

4282

*** ISCLT2 - VERSION 93109 *** *** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
 *** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93
 15:11:18
 PAGE 8

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** AVERAGE MIXING LAYER HEIGHT (METERS) ***

	WIND SPEED	WIND SPEED	ANNUAL WIND SPEED	WIND SPEED	WIND SPEED	WIND SPEED
	CATEGORY 1	CATEGORY 2	CATEGORY 3	CATEGORY 4	CATEGORY 5	CATEGORY 6
STABILITY CATEGORY A	2105.0000	1961.0000	1803.0000	1802.0000	1526.0000	2349.0000
STABILITY CATEGORY B	1403.0000	1307.0000	1202.0000	1201.0000	1017.0000	1566.0000
STABILITY CATEGORY C	1403.0000	1307.0000	1202.0000	1201.0000	1017.0000	1566.0000
STABILITY CATEGORY D	1403.0000	1307.0000	1202.0000	1201.0000	1017.0000	1566.0000
STABILITY CATEGORY E	5000.0000	5000.0000	5000.0000	5000.0000	5000.0000	5000.0000
STABILITY CATEGORY F	5000.0000	5000.0000	5000.0000	5000.0000	5000.0000	5000.0000

0277

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 9

MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** FREQUENCY OF OCCURRENCE OF WIND SPEED, DIRECTION AND STABILITY ***

FILE: C:\MODELS\ISCLT2\FENP87.STR

FORMAT: (7X,6F7.6)

SURFACE STATION NO.: 0

UPPER AIR STATION NO.: 0

NAME: FEMP

NAME: DAYTON

YEAR: 1987

YEAR: 1900

ANNUAL: STABILITY CATEGORY A

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.500 M/S)	WIND SPEED CATEGORY 2 (2.500 M/S)	WIND SPEED CATEGORY 3 (4.300 M/S)	WIND SPEED CATEGORY 4 (6.800 M/S)	WIND SPEED CATEGORY 5 (9.500 M/S)	WIND SPEED CATEGORY 6 (12.500 M/S)
0.000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
22.500	0.00013800	0.00000000	0.00013800	0.00013800	0.00000000	0.00000000
45.000	0.00013800	0.00000000	0.00013800	0.00013800	0.00000000	0.00000000
67.500	0.00013800	0.00027600	0.00082800	0.00000000	0.00000000	0.00000000
90.000	0.00000000	0.00055200	0.00069000	0.00013800	0.00000000	0.00000000
112.500	0.00013800	0.00027600	0.00027600	0.00000000	0.00000000	0.00000000
135.000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
157.500	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
180.000	0.00000000	0.00000000	0.00013800	0.00000000	0.00000000	0.00000000
202.500	0.00000000	0.00041400	0.00151700	0.00000000	0.00000000	0.00000000
225.000	0.00000000	0.00124100	0.00344700	0.00041400	0.00000000	0.00000000
247.500	0.00000000	0.00096600	0.00234400	0.00000000	0.00000000	0.00000000
270.000	0.00000000	0.00082800	0.00137900	0.00000000	0.00000000	0.00000000
292.500	0.00000000	0.00027600	0.00069000	0.00041400	0.00000000	0.00000000
315.000	0.00013800	0.00013800	0.00027600	0.00055200	0.00000000	0.00000000
337.500	0.00000000	0.00000000	0.00041400	0.00041400	0.00013800	0.00000000

ANNUAL: STABILITY CATEGORY B

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.500 M/S)	WIND SPEED CATEGORY 2 (2.500 M/S)	WIND SPEED CATEGORY 3 (4.300 M/S)	WIND SPEED CATEGORY 4 (6.800 M/S)	WIND SPEED CATEGORY 5 (9.500 M/S)	WIND SPEED CATEGORY 6 (12.500 M/S)
0.000	0.00000000	0.00041400	0.00013800	0.00000000	0.00000000	0.00000000
22.500	0.00000000	0.00027600	0.00055200	0.00000000	0.00000000	0.00000000
45.000	0.00000000	0.00082800	0.00234400	0.00013800	0.00000000	0.00000000
67.500	0.00027600	0.00082800	0.00027600	0.00069000	0.00000000	0.00000000
90.000	0.00027600	0.00069000	0.00027600	0.00013800	0.00000000	0.00000000
112.500	0.00000000	0.00082800	0.00000000	0.00000000	0.00000000	0.00000000
135.000	0.00000000	0.00013800	0.00000000	0.00000000	0.00000000	0.00000000
157.500	0.00013800	0.00027600	0.00013800	0.00013800	0.00000000	0.00000000
180.000	0.00013800	0.00013800	0.00013800	0.00000000	0.00000000	0.00000000
202.500	0.00013800	0.00096600	0.00206900	0.00027600	0.00000000	0.00000000
225.000	0.00027600	0.00124100	0.00275800	0.00013800	0.00000000	0.00000000
247.500	0.00055200	0.00110300	0.00206900	0.00000000	0.00000000	0.00000000
270.000	0.00013800	0.00096600	0.00137900	0.00013800	0.00000000	0.00000000
292.500	0.00000000	0.00069000	0.00082800	0.00027600	0.00000000	0.00000000
315.000	0.00027600	0.00110300	0.00082800	0.00055200	0.00000000	0.00000000
337.500	0.00000000	0.00013800	0.00041400	0.00000000	0.00000000	0.00000000

0278

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4787

*** ISCLT2 - VERSION 93109 *** *** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
 *** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93
 15:11:18
 PAGE 10

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** FREQUENCY OF OCCURRENCE OF WIND SPEED, DIRECTION AND STABILITY ***

FILE: C:\MODELS\ISCLT2\FEMP87.STR

FORMAT: (7X,6F7.6)

SURFACE STATION NO.: 0

UPPER AIR STATION NO.: 0

NAME: FEMP

NAME: DAYTON

YEAR: 1987

YEAR: 1900

ANNUAL: STABILITY CATEGORY C

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.500 M/S)	WIND SPEED CATEGORY 2 (2.500 M/S)	WIND SPEED CATEGORY 3 (4.300 M/S)	WIND SPEED CATEGORY 4 (6.800 M/S)	WIND SPEED CATEGORY 5 (9.500 M/S)	WIND SPEED CATEGORY 6 (12.500 M/S)
0.000	0.00027600	0.00069000	0.00082800	0.00000000	0.00000000	0.00000000
22.500	0.00013800	0.00069000	0.00096600	0.00000000	0.00000000	0.00000000
45.000	0.00027600	0.00124100	0.00137900	0.00041400	0.00000000	0.00000000
67.500	0.00069000	0.00206900	0.00055200	0.00124100	0.00000000	0.00000000
90.000	0.00041400	0.00124100	0.00027600	0.00013800	0.00000000	0.00000000
112.500	0.00055200	0.00069000	0.00000000	0.00000000	0.00000000	0.00000000
135.000	0.00027600	0.00027600	0.00000000	0.00000000	0.00000000	0.00000000
157.500	0.00013800	0.00027600	0.00013800	0.00000000	0.00000000	0.00000000
180.000	0.00041400	0.00082800	0.00041400	0.00000000	0.00000000	0.00000000
202.500	0.00041400	0.00151700	0.00082800	0.00013800	0.00000000	0.00000000
225.000	0.00137900	0.00386100	0.00193100	0.00027600	0.00000000	0.00000000
247.500	0.00110300	0.00372300	0.00137900	0.00041400	0.00000000	0.00000000
270.000	0.00041400	0.00124100	0.00110300	0.00041400	0.00000000	0.00000000
292.500	0.00041400	0.00124100	0.00124100	0.00027600	0.00000000	0.00000000
315.000	0.00027600	0.00096600	0.00082800	0.00027600	0.00013800	0.00000000
337.500	0.00027600	0.00137900	0.00110300	0.00000000	0.00000000	0.00000000

ANNUAL: STABILITY CATEGORY D

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.500 M/S)	WIND SPEED CATEGORY 2 (2.500 M/S)	WIND SPEED CATEGORY 3 (4.300 M/S)	WIND SPEED CATEGORY 4 (6.800 M/S)	WIND SPEED CATEGORY 5 (9.500 M/S)	WIND SPEED CATEGORY 6 (12.500 M/S)
0.000	0.00292500	0.00565300	0.00979000	0.00082800	0.00000000	0.00000000
22.500	0.00238600	0.00979000	0.01089300	0.00413700	0.00000000	0.00000000
45.000	0.00475900	0.01585600	0.01089300	0.00193100	0.00000000	0.00000000
67.500	0.00852300	0.02426600	0.01764800	0.00524000	0.00000000	0.00000000
90.000	0.00666100	0.00579100	0.00151700	0.00013800	0.00000000	0.00000000
112.500	0.00388300	0.00262000	0.00000000	0.00000000	0.00000000	0.00000000
135.000	0.00305300	0.00248200	0.00055200	0.00000000	0.00000000	0.00000000
157.500	0.00277700	0.00289600	0.00151700	0.00055200	0.00000000	0.00000000
180.000	0.00430700	0.00510200	0.00206900	0.00027600	0.00000000	0.00000000
202.500	0.00516200	0.01227100	0.00413700	0.00165500	0.00000000	0.00000000
225.000	0.00615500	0.01944100	0.00923800	0.00082800	0.00055200	0.00000000
247.500	0.00724200	0.01365000	0.00675600	0.00386100	0.00027600	0.00000000
270.000	0.00571900	0.01351200	0.01447700	0.00372300	0.00000000	0.00000000
292.500	0.00433500	0.01337400	0.00799700	0.00151700	0.00000000	0.00000000
315.000	0.00294000	0.00992700	0.00799700	0.00165500	0.00041400	0.00000000
337.500	0.00459600	0.00882400	0.00606700	0.00248200	0.00027600	0.00000000

0279

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 11

* MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** FREQUENCY OF OCCURRENCE OF WIND SPEED, DIRECTION AND STABILITY ***

FILE: C:\MODELS\ISCLT2\FEMP87.STR

FORMAT: (7X,6F7.6)

SURFACE STATION NO.: 0

UPPER AIR STATION NO.: 0

NAME: FEMP

NAME: DAYTON

YEAR: 1987

YEAR: 1900

ANNUAL: STABILITY CATEGORY E

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.500 M/S)	WIND SPEED CATEGORY 2 (2.500 M/S)	WIND SPEED CATEGORY 3 (4.300 M/S)	WIND SPEED CATEGORY 4 (6.800 M/S)	WIND SPEED CATEGORY 5 (9.500 M/S)	WIND SPEED CATEGORY 6 (12.500 M/S)
0.000	0.00348700	0.00524000	0.00069000	0.00013800	0.00000000	0.00000000
22.500	0.00250800	0.00317200	0.00179300	0.00027600	0.00000000	0.00000000
45.000	0.00320300	0.00372300	0.00082800	0.00000000	0.00000000	0.00000000
67.500	0.01251900	0.01199600	0.00193100	0.00000000	0.00000000	0.00000000
90.000	0.01164800	0.00317200	0.00027600	0.00000000	0.00000000	0.00000000
112.500	0.00638100	0.00206900	0.00013800	0.00000000	0.00000000	0.00000000
135.000	0.00486000	0.00262000	0.00096600	0.00000000	0.00000000	0.00000000
157.500	0.00666100	0.00289600	0.00124100	0.00055200	0.00000000	0.00000000
180.000	0.00694500	0.00441200	0.00262000	0.00013800	0.00000000	0.00000000
202.500	0.00905500	0.01158200	0.00441200	0.00041400	0.00000000	0.00000000
225.000	0.01422800	0.02233600	0.00620500	0.00110300	0.00013800	0.00000000
247.500	0.02136700	0.00841100	0.00413700	0.00110300	0.00000000	0.00000000
270.000	0.01320100	0.00965200	0.00399900	0.00027600	0.00000000	0.00000000
292.500	0.00736900	0.00634300	0.00234400	0.00013800	0.00000000	0.00000000
315.000	0.00971200	0.00372300	0.00193100	0.00027600	0.00000000	0.00000000
337.500	0.00818500	0.00289600	0.00137900	0.00013800	0.00000000	0.00000000

ANNUAL: STABILITY CATEGORY F

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.500 M/S)	WIND SPEED CATEGORY 2 (2.500 M/S)	WIND SPEED CATEGORY 3 (4.300 M/S)	WIND SPEED CATEGORY 4 (6.800 M/S)	WIND SPEED CATEGORY 5 (9.500 M/S)	WIND SPEED CATEGORY 6 (12.500 M/S)
0.000	0.00657000	0.00013800	0.00000000	0.00000000	0.00013800	0.00013800
22.500	0.00599400	0.00000000	0.00013800	0.00000000	0.00000000	0.00000000
45.000	0.00628000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
67.500	0.01264600	0.00248200	0.00000000	0.00000000	0.00000000	0.00000000
90.000	0.01728800	0.00055200	0.00000000	0.00000000	0.00000000	0.00000000
112.500	0.01355800	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
135.000	0.00686000	0.00027600	0.00000000	0.00000000	0.00000000	0.00000000
157.500	0.00428700	0.00013800	0.00000000	0.00000000	0.00000000	0.00000000
180.000	0.00570900	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
202.500	0.01001900	0.00082800	0.00000000	0.00000000	0.00000000	0.00000000
225.000	0.02047600	0.00193100	0.00000000	0.00000000	0.00000000	0.00000000
247.500	0.02687400	0.00124100	0.00000000	0.00000000	0.00000000	0.00000000
270.000	0.02841500	0.00041400	0.00000000	0.00000000	0.00000000	0.00000000
292.500	0.02541300	0.00027600	0.00000000	0.00000000	0.00000000	0.00000000
315.000	0.02255400	0.00013800	0.00000000	0.00000000	0.00000000	0.00000000
337.500	0.01428100	0.00027600	0.00000000	0.00000000	0.00000000	0.00000000

SUM OF FREQUENCIES, FTOTAL = 1.00012

0280

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 12

* MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OUIPIT1 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)								
	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00
500.00	1022.053160	1085.831300	1296.783450	1421.270020	1373.525880	1404.821170	1479.903320	1840.248540	2192.871340
450.00	1126.456670	1189.198120	1380.903080	1642.401000	1613.959470	1581.564700	1675.514650	2111.441410	2534.762210
400.00	1244.236820	1325.261230	1466.339360	1785.710330	1913.416500	1835.068970	1913.940920	2448.836430	2963.637210
350.00	1486.657590	1484.143800	1589.042360	1939.542240	2288.416750	2222.513670	2208.559080	2875.749270	3511.170170
300.00	1893.147460	1808.600340	1805.134520	2099.230470	2614.258060	2723.565920	2578.519290	3426.845460	4224.821780
250.00	2292.108150	2355.591310	2250.421630	2254.238280	2915.233150	3381.205320	3254.103760	4155.359380	5178.059080
200.00	2478.807860	2904.387210	3012.533450	2879.966800	3244.398680	4159.378420	4184.982910	5145.962400	6489.020020
150.00	2647.068120	3173.587650	3797.974610	3989.422850	3977.421880	4831.912110	5495.569340	6769.690430	8357.000000
100.00	3363.845700	3411.985110	4204.234380	5171.976070	5529.932620	6244.960940	7392.650390	9454.234380	11152.445300
50.00	4680.561040	5056.764650	5383.854000	6113.254880	7433.739750	8794.131840	10459.351600	13835.923800	19229.693400
0.00	5303.461430	6495.558590	7791.831050	8817.907230	10796.494100	13034.163100	16039.861300	23522.396500	35688.414100
-50.00	5446.415530	6776.837890	8614.766600	11232.133800	15130.850600	20508.462900	30679.814500	50881.703100	69648.992200
-100.00	7425.901370	9140.899410	11532.711900	15379.068400	21684.128900	32330.960900	59292.718800	69052.421900	0.000000
-150.00	8266.471680	10228.296900	12975.816400	17254.029300	24718.720700	37845.773400	68602.625000	91156.015600	0.000000
-200.00	7639.341800	9632.005860	12539.340800	16782.572300	23299.744100	32608.550800	47137.531300	71701.125000	70976.671900
-250.00	8014.775390	10048.896500	12781.612300	14587.514600	17615.355500	21410.755900	25055.091800	31296.021500	36285.914100
-300.00	7878.349610	8614.426760	9346.405270	10570.973600	12161.930700	13752.050800	14661.638700	16121.943400	19757.822300
-350.00	5999.276860	6239.097660	7118.969240	8350.208980	8783.257810	8864.635740	9236.916020	10716.000000	11811.610400
-400.00	4675.613770	5307.591800	6061.793950	6250.409180	5775.867190	6070.785640	6683.561520	7451.470700	8617.325200
-450.00	4099.411130	4589.239260	4666.700680	4226.924800	4176.278320	5113.969240	4954.343750	5488.094240	6648.625000
-500.00	3589.748290	3614.202880	3276.233400	3001.195070	3662.055180	4119.696290	3748.172850	4399.703610	5277.515140

0281

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 13

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QU1PIT1 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)								
	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00
500.00	2168.730710	2206.352290	2285.385990	2734.104740	3259.722410	3176.398930	3079.542720	3070.087400	3033.366460
450.00	2501.764890	2539.222410	2692.464600	3415.736570	3737.190670	3581.176510	3515.577640	3476.373290	3408.577150
400.00	2917.691410	2952.259030	3491.406980	4287.690920	4285.750490	4075.094240	4029.011470	3948.209720	4193.344730
350.00	3443.843260	3472.513670	4541.077640	5207.167480	4940.697270	4749.755370	4644.810550	4949.848140	5188.788570
300.00	4129.672850	4628.812990	5936.591310	6128.001950	5722.521000	5563.450680	5963.657230	6247.232910	5816.600590
250.00	5035.244140	6365.866210	7760.972660	7263.800780	6796.255860	7338.436520	7689.762210	7090.802250	6098.964840
200.00	6703.461910	8822.394530	9476.303710	8666.940430	9270.834960	9710.733400	8845.133790	7477.558110	6451.646000
150.00	10010.714800	12366.405300	11698.470700	12112.504900	12666.200200	11354.466800	9392.851560	7947.782710	7026.186520
100.00	15179.497100	16507.806600	17055.716800	17234.445300	15120.513700	12161.994100	10219.040000	9368.803710	8548.415040
50.00	23647.652300	25982.525400	24886.789100	21136.835900	17208.939500	14598.472700	12927.520500	11455.719700	9700.786130
0.00	45048.699200	41370.773400	34670.472700	27029.408200	21703.394500	18404.189500	14317.951200	11281.863300	9018.966800
-50.00	92253.765600	65732.031300	45886.265600	32558.369100	23384.695300	17291.650400	13089.499000	10279.052700	8655.065430
-100.00	163625.531000	93172.593800	52466.890600	34563.347700	23899.252000	18059.550800	14420.715800	11781.336900	9807.972660
-150.00	153793.469000	89133.656300	48637.953100	32521.388700	22891.373000	17749.603500	14172.021500	11579.750000	9642.767580
-200.00	83767.117200	57429.179700	39272.558600	27054.919900	19681.212900	14775.744100	11377.292000	9243.965820	7819.227050
-250.00	39931.300800	35131.320300	27929.062500	21590.763700	17494.935500	14500.074200	11408.147500	9128.897460	7416.050290
-300.00	21626.685500	21951.459000	19756.351600	15929.177700	13274.603500	11428.857400	10228.841800	9142.356450	7608.287600
-350.00	14156.029300	14209.636700	14001.682600	13530.041000	11279.887700	8892.476560	7740.704100	7211.632810	6661.977540
-400.00	9582.805660	11047.154300	9761.728520	9764.910160	9843.962890	8423.976560	6845.225590	5791.314450	5206.564450
-450.00	6643.325200	8024.907710	8114.729980	7040.949220	7378.865720	7484.809570	6532.870120	5434.327150	4689.657710
-500.00	4974.135740	5921.811040	6807.246580	6057.964360	5446.814940	5779.566410	5886.086430	5217.348140	4421.770020

0282

789

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 14

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OUIPIT1 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	400.00	450.00	500.00	X-COORD (METERS)
---------------------	--------	--------	--------	------------------

500.00	2976.166260	3136.819580	3278.115230	
450.00	3605.323730	3772.447270	3587.763180	
400.00	4392.950680	4156.236330	3711.827880	
350.00	4877.176760	4313.614750	3877.258790	
300.00	5081.112300	4519.938480	4154.724610	
250.00	5344.631350	4864.236330	4436.907710	
200.00	5789.346680	5212.372560	4816.514160	
150.00	6518.738770	6066.681150	5644.826170	
100.00	7789.719240	7025.535160	5949.097660	
50.00	7968.599120	6610.010740	5533.086910	
0.00	7303.562990	6274.583010	5497.397950	
-50.00	7389.432620	6384.546390	5573.585940	
-100.00	8294.603520	7109.081050	6163.192870	
-150.00	8157.758790	6994.541990	6066.404300	
-200.00	6704.740720	5816.478520	5096.927250	
-250.00	6155.192380	5381.679690	4746.903810	
-300.00	6339.823730	5336.054690	4532.876950	
-350.00	6131.390630	5438.627440	4667.153320	
-400.00	4950.364260	4668.130860	4391.483400	
-450.00	4213.767580	3798.785400	3619.500240	
-500.00	3876.476810	3534.805660	3231.436520	

0283

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

PAGE 15

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OUIPIT1 ***

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF POLL1 IN MICROGRAMS/M**3

**

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
-1825.00	-2865.00	128.272934	-3460.00	3870.00	50.567192
4722.00	1960.00	203.674042	6470.00	-4590.00	79.180611
5500.00	3460.00	140.507401	5000.00	2390.00	180.162872

0284

4287

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 16

** MODELING OPTIONS USED: CONC RURAL FLAT DEFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QU1PIT2 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00
500.00	657.237976	699.157227	740.474915	780.015869	944.414978	1003.842350	984.658569	1052.983760	1126.928710
450.00	767.320984	772.108521	825.896851	878.967651	1013.139470	1194.974610	1146.892820	1205.386110	1299.271850
400.00	964.344849	916.487366	924.942200	994.990417	1080.419190	1358.994020	1397.317750	1394.202640	1515.935550
350.00	1084.350590	1177.302000	1119.222780	1130.776000	1222.817870	1492.195560	1723.253050	1633.125980	1793.702640
300.00	1152.468510	1340.809200	1472.508420	1399.863040	1415.870610	1629.735840	2112.983640	2082.535400	2158.119380
250.00	1313.507930	1434.897220	1701.542850	1896.278560	1804.395390	1826.697270	2405.552250	2707.283200	2649.541750
200.00	1497.053470	1652.944950	1836.238650	2231.254150	2535.222660	2418.360110	2730.824710	3597.349120	3509.284180
150.00	1973.594850	2023.990480	2141.386470	2432.712650	3053.056640	3562.026120	3431.768070	4467.274900	4988.372070
100.00	2483.646970	2879.383790	3096.645260	3268.943360	3371.339840	4423.823730	5370.195800	6128.568850	7431.083500
50.00	2562.892580	3104.621090	3820.910640	4786.836430	5485.218260	6158.998540	7471.176760	9484.295900	12512.820300
0.00	2809.720460	3316.350340	3977.903560	5019.941410	6601.946290	8997.443360	12081.322300	16973.205100	26376.337900
-50.00	3605.745610	4349.377930	5355.394040	6763.383790	8824.005860	12196.937500	18490.595700	30781.761700	62202.351600
-100.00	3979.203370	4825.288090	5975.736330	7594.114750	9971.460940	13887.787100	21433.960900	36175.398400	74477.007800
-150.00	3781.276610	4550.685060	5580.723630	7204.251950	9730.775390	13662.798800	18766.138700	25806.630900	37334.003900
-200.00	3806.186520	4717.773930	5951.844240	7661.623540	8912.919920	10077.192400	12165.292000	14604.810500	16396.785200
-250.00	4033.591310	4798.526370	5215.486330	5602.719730	5890.801270	7237.535160	8300.123050	8317.499020	8777.562500
-300.00	3422.332760	3584.904790	3799.028810	4181.775390	4932.291020	5440.295900	4837.386720	5486.920900	5708.347660
-350.00	2677.267330	2889.116940	3110.929200	3564.222170	3836.261720	3401.350340	3480.370360	4315.636720	3882.190430
-400.00	2265.299320	2399.694340	2690.914310	2846.620360	2527.850830	2404.509280	2974.264160	3160.777590	2852.765630
-450.00	1905.123290	2101.491940	2195.212890	1954.961430	1869.050050	2084.995360	2550.403810	2364.698240	2303.455810
-500.00	1685.905640	1744.495240	1558.962770	1496.110110	1595.119870	1855.364870	2036.757450	1802.070920	1900.028810

0285

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4782

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 17

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QU1PIT2 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)									
	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00	
500.00	1499.862430	1557.992430	1597.734990	1670.032470	1904.026490	2334.836670	2250.816410	2230.441650	2221.013430	
450.00	1759.565670	1828.696780	1871.151370	1950.749390	2463.594240	2703.698970	2592.945310	2586.613770	2545.989260	
400.00	2094.015630	2176.884280	2220.368650	2473.860350	3200.682860	3150.592530	3060.443120	3015.543700	2953.542720	
350.00	2534.725590	2634.739500	2675.389650	3376.256100	3930.070310	3693.539550	3634.411620	3557.610110	3859.003420	
300.00	3131.684080	3252.902830	3336.693360	4634.814940	4732.895510	4472.545410	4377.735350	4781.391600	4696.488280	
250.00	3967.361330	4114.062990	4940.237300	6241.685060	5750.715330	5532.438480	6093.295900	5941.864260	4969.019040	
200.00	5186.708980	5361.142580	7380.368160	7901.805180	7235.194340	8051.849120	7770.851560	6339.354490	5375.815430	
150.00	7087.620610	8433.736330	11219.798800	10278.405300	11168.324200	10614.497100	8379.919920	6912.692380	6004.749510	
100.00	10404.690400	14630.794900	16053.714800	16638.334000	15387.417000	11608.479500	9647.744140	8577.407230	7598.592290	
50.00	19036.449200	26932.810500	29116.437500	24486.468800	18822.238300	15129.829100	12734.812500	9899.233400	7611.733890	
0.00	50125.472700	67888.148400	52717.453100	35056.890600	24847.742200	16957.697300	12039.903300	8808.911130	7134.499020	
-50.00	0.000000139991	1.25000	79944.289100	41572.355500	25303.533200	16986.127000	12789.772500	9985.580080	8015.342770	
-100.00	0.000000115199	8.67000	72433.195300	37757.195300	23552.294900	16164.751000	12199.522500	9547.409180	7680.984860	
-150.00	53786.851600	57130.062500	41754.050800	27667.130900	19681.892600	13761.091800	10011.385700	7510.687010	6172.002930	
-200.00	19741.857400	23531.326200	22860.332000	18337.816400	14259.126000	11637.958000	9957.787110	7846.776370	6161.064940	
-250.00	10673.256800	13138.094700	13334.796900	12787.925800	11415.054700	8439.981450	7127.373050	6490.016600	5851.059080	
-300.00	7189.252440	7908.549320	9642.207030	8288.143550	8508.092770	7831.503420	6071.807130	4983.427250	4380.348630	
-350.00	5241.946290	5199.837400	6507.801270	6572.065920	5702.175780	6086.148930	5708.493160	4580.766600	3867.545170	
-400.00	3995.164550	3984.738280	4496.749020	5356.657710	4652.459960	4306.503910	4576.370610	4349.279300	3582.580080	
-450.00	3143.636230	3147.234130	3161.327150	4083.914310	3948.339840	3555.352780	3373.933590	3571.969240	3427.347410	
-500.00	2537.319090	2546.926270	2539.599610	3051.492190	3371.930180	3005.947270	2855.247560	2719.559570	2869.781250	

0286

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 18

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OUIPIT2 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	400.00	450.00	500.00	X-COORD (METERS)
---------------------	--------	--------	--------	------------------

500.00	2188.198490	2150.524660	2301.079350	
450.00	2499.919920	2686.693120	2675.847410	
400.00	3185.803220	3162.439210	2780.035890	
350.00	3810.363280	3300.984380	2949.411130	
300.00	4004.749760	3525.393310	3191.403560	
250.00	4303.055180	3843.737300	3442.599370	
200.00	4722.209470	4165.175290	3840.809080	
150.00	5510.972170	5034.317380	4593.194340	
100.00	6511.778810	5262.108890	4300.630370	
50.00	5955.077640	4897.008300	4211.675290	
0.00	5925.276860	5001.144040	4279.545410	
-50.00	6579.461910	5500.912600	4670.363280	
-100.00	6318.291500	5292.867680	4501.810550	
-150.00	5171.981450	4400.091310	3791.919430	
-200.00	4922.938480	4123.381840	3580.075440	
-250.00	5069.178220	4172.977050	3474.008060	
-300.00	4115.896480	3827.307370	3541.245850	
-350.00	3408.175540	3014.752440	2838.226560	
-400.00	3090.412840	2768.953860	2486.780760	
-450.00	2881.863040	2528.068600	2295.302250	
-500.00	2773.416500	2371.603030	2113.789550	

0287

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4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 19

* MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QU1PIT2 ***

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF POLL1 IN MICROGRAMS/M**3

**

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
-1825.00	-2865.00	75.847496	-3460.00	3870.00	30.949781
4722.00	1960.00	127.745636	6470.00	-4590.00	48.432926
5500.00	3460.00	87.498642	5000.00	2390.00	112.596115

0288

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 20

** MODELING OPTIONS USED: CONC RURAL FLAT DEFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OU1P3SQ1 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00
500.00	1313.114380	1312.066650	1408.846680	1685.696170	2025.965820	1962.002320	1975.812990	2554.502200	3109.097410
450.00	1683.737430	1607.388790	1606.107670	1820.088130	2302.897710	2424.305420	2320.214360	3063.781980	3766.618650
400.00	1994.567750	2110.747800	2015.750850	2013.494020	2569.230470	3037.987550	2911.455320	3744.672850	4655.293460
350.00	2152.589600	2544.469730	2725.279050	2605.914060	2855.543950	3736.183350	3792.692630	4683.444340	5894.894530
300.00	2367.532960	2773.823000	3357.059080	3654.499270	3513.602780	4355.862300	5056.205570	6159.967770	7693.399900
250.00	3080.614260	3125.459720	3706.156250	4627.149900	5152.733890	5687.158690	6931.742680	8813.924800	10532.844700
200.00	4290.949710	4677.228520	5033.845210	5609.457030	6766.463870	8137.426760	9920.405270	13273.751000	18724.078100
150.00	4616.590820	5705.283200	7182.355960	8370.181640	10154.070300	12608.194300	15610.593800	23612.082000	36270.371100
100.00	5000.845700	6109.858890	7873.100590	10451.065400	14427.002900	20890.998000	32315.476600	55045.515600	74992.007800
50.00	6782.637210	8419.267580	10732.203100	14161.860400	20237.597700	31462.597700	58950.605500	64457.906300	0.000000
0.00	7036.388180	8734.882810	11127.894500	15094.751000	21837.388700	33464.460900	60928.671900	87959.976600	0.000000
-50.00	6582.860840	8400.266600	10973.087900	14738.125000	19737.849600	25967.679700	36567.226600	50938.238300	62750.433600
-100.00	7039.864260	8847.642580	10368.687500	11640.418000	13889.931600	16278.387700	18950.857400	21304.173800	26584.599600
-150.00	6372.208500	6872.465820	7300.420410	8333.218750	10054.356400	10497.165000	10496.468800	12499.730500	14608.401400
-200.00	4716.606450	5062.160640	5907.006350	6876.608890	6689.391110	6405.622070	7353.872070	8247.522460	9289.519530
-250.00	3858.382320	4390.396000	4981.208010	4784.124510	4190.113280	5053.179690	5285.843750	5706.446780	6924.900880
-300.00	3384.418460	3766.761720	3588.982180	3093.843750	3479.641850	4248.898440	3894.786870	4460.757810	5354.723140
-350.00	2944.804930	2791.949220	2427.742190	2494.715820	3046.786130	3289.065670	2930.586910	3582.149900	4258.891110
-400.00	2234.609130	1958.126590	2009.734010	2249.293460	2674.433590	2579.418700	2365.982420	2940.100830	3465.629150
-450.00	1614.584350	1654.797730	1747.694460	2029.347410	2247.554440	2049.563230	2009.142700	2457.043950	2873.903560
-500.00	1388.348880	1461.298710	1571.473880	1831.649900	1837.103150	1669.823360	1728.006710	2084.649410	2421.286130

0289

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 21

MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OUIP3SQ1 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)								
	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00
500.00	3041.553470	3118.006590	4120.097170	4576.301760	4322.801760	4218.991210	4115.402340	4436.448730	4630.974610
450.00	3667.165530	4223.528320	5428.267090	5403.955080	5085.453130	4958.476560	5380.407230	5610.244630	4952.641110
400.00	4503.990720	5871.452150	6913.029790	6426.693360	6102.296390	6674.669920	6953.784670	6053.165040	5168.643550
350.00	6121.467290	8232.081050	8486.772460	7709.948240	8519.115230	8857.284180	7576.084960	6347.469730	5605.877440
300.00	9317.622070	11622.972700	10532.130900	11280.353500	11680.255900	9768.665040	7990.224610	6929.270510	6155.646970
250.00	14440.809600	15174.501000	15849.691400	16123.212900	13088.286100	10373.798800	9125.091800	8307.679690	7537.200200
200.00	23030.275400	24869.767600	23725.744100	18454.402300	15103.788100	13120.471700	11518.429700	9952.361330	8025.311040
150.00	44529.238300	41125.976600	31581.802700	23964.039100	19649.775400	15436.334000	11829.343800	9228.860350	7314.201660
100.00	94881.734400	61809.304700	41854.226600	27884.253900	19630.640600	14289.722700	10857.057600	8946.387700	7501.376460
50.00	151107.859000	79352.585900	44393.230500	28551.003900	20460.802700	15775.105500	12532.086900	10196.959000	8461.420900
0.00	121445.070000	66662.304700	39474.953100	26298.177700	18448.589800	14168.734400	11332.410200	9275.767580	7737.499020
-50.00	59670.082000	42348.937500	29905.250000	22060.820300	16095.720700	12101.222700	9323.849610	7510.572750	6371.197750
-100.00	29689.283200	25951.209000	21347.058600	16829.789100	13844.292000	11957.351600	9623.535160	7703.698240	6258.873050
-150.00	16785.367200	16788.587900	15614.752900	13167.382800	10172.934600	8919.351560	8103.377440	7319.280760	6396.276860
-200.00	10924.301800	11519.897500	10785.621100	10746.682600	9352.928710	7386.138670	6105.835940	5656.477050	5290.028810
-250.00	7344.654300	8863.562500	7939.771970	7639.397950	7851.123050	6986.396000	5684.730960	4819.390630	4273.962400
-300.00	5048.277830	6412.031740	6607.336910	5740.379880	5813.467770	5991.141110	5420.153810	4513.567870	3902.053710
-350.00	3998.083500	4710.820800	5548.720700	4944.239750	4491.526370	4579.629880	4726.479490	4330.800780	3673.592040
-400.00	3277.247310	3504.289550	4324.472170	4276.553220	3831.850100	3642.139160	3706.465820	3827.804930	3542.803960
-450.00	2733.615720	2778.458500	3361.552980	3719.361570	3374.685300	3165.141110	3016.497070	3065.453610	3172.843750
-500.00	2314.119380	2360.948970	2634.735350	3128.778810	2995.281980	2763.385250	2660.349850	2548.400150	2592.929690

4787

*** ISCLT2 - VERSION 93109 *** *** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
 *** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93
 15:11:18
 PAGE 22

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: Q01P3SQ1 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	400.00	450.00	500.00	X-COORD (METERS)
---------------------	--------	--------	--------	------------------

500.00	4142.011720	3645.125730	3342.434330	
450.00	4297.794430	3904.355710	3580.207520	
400.00	4630.693850	4199.446290	3820.627440	
350.00	5012.086430	4496.751950	4202.777340	
300.00	5728.164550	5309.816890	4922.529790	
250.00	6836.097170	5818.840330	4900.563480	
200.00	6546.819340	5397.215330	4587.231450	
150.00	6184.457520	5354.791500	4682.260740	
100.00	6382.681640	5499.312990	4789.652340	
50.00	7136.821780	6103.318360	5281.484860	
0.00	6556.861330	5630.947750	4891.241210	
-50.00	5476.107420	4760.213380	4178.593260	
-100.00	5153.093750	4505.831050	3977.207280	
-150.00	5332.625490	4489.692380	3814.810790	
-200.00	4912.945310	4548.205080	3919.250730	
-250.00	3901.278560	3716.898930	3524.552490	
-300.00	3512.343260	3171.206050	2879.661130	
-350.00	3225.625730	2946.745850	2697.306880	
-400.00	3057.042970	2727.074460	2516.001220	
-450.00	2967.863280	2595.637940	2339.351070	
-500.00	2684.315190	2528.230710	2234.148930	

0291

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 23

* MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OU1P3SQ1 ***

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF POLL1 IN MICROGRAMS/M**3

**

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
-1825.00	-2865.00	100.335518	-3460.00	3870.00	44.342705
4722.00	1960.00	174.925323	6470.00	-4590.00	65.315712
5500.00	3460.00	121.090607	5000.00	2390.00	155.003052

0292

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 24

* MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: CU1P3SQ2 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)								
	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00
500.00	1131.704710	1080.538820	1074.440920	1155.845340	1298.106570	1618.705320	1629.692500	1622.816770	1892.463870
450.00	1277.064210	1384.269410	1322.606450	1315.020630	1422.023070	1787.848140	2011.816650	1905.448850	2254.421630
400.00	1359.813110	1582.099000	1734.673460	1658.731570	1648.708250	1968.089110	2517.513430	2432.112790	2734.256840
350.00	1530.778320	1696.757200	2012.144780	2238.845210	2145.008790	2145.826900	2894.181400	3165.750000	3389.489010
300.00	1743.589480	1928.631470	2176.896730	2645.298340	3001.064940	2886.261470	3318.819340	4213.984860	4521.764650
250.00	2369.879150	2455.706300	2501.890630	2892.850590	3630.614750	4229.895510	4308.420410	5402.136230	6462.221190
200.00	2917.177000	3442.106690	3734.019780	3992.510990	4233.916500	5280.762210	6405.806640	7652.875490	9702.482420
150.00	3006.626950	3648.333980	4499.344240	5651.300780	6646.972170	7699.948240	9516.176760	11858.144500	17212.767600
100.00	3276.965090	3874.923580	4658.421390	5911.929200	7795.832520	10665.801800	14948.300800	21298.800800	37881.019500
50.00	4360.003420	5276.614260	6521.443850	8271.229490	10845.418000	15119.838900	23014.119100	40430.269500	79146.273400
0.00	4617.038090	5599.478520	6934.486330	8810.500000	11562.217800	16620.980500	25487.373000	44083.582000	81319.156300
-50.00	4387.852540	5279.259280	6550.655760	8564.395510	11519.304700	16081.422900	21008.351600	28468.095700	41054.203100
-100.00	4496.185550	5561.225590	6996.735350	8675.536130	9775.322270	11281.391600	13386.310500	15918.302700	18287.470700
-150.00	4721.008300	5328.609380	5762.101070	6145.856930	6730.258790	8190.142090	8808.562500	8970.175780	10014.254900
-200.00	3800.484130	3960.809330	4237.692380	4781.571780	5601.098140	5838.753910	5340.669430	6232.300290	6563.805660
-250.00	3000.792240	3229.415040	3559.861080	4057.679690	4150.299320	3617.721440	4025.169680	4651.564940	4502.662110
-300.00	2536.759030	2747.801270	3069.118900	3098.717770	2715.215580	2734.373780	3418.137700	3421.687260	3399.981450
-350.00	2182.673340	2400.174320	2401.398680	2115.647460	2091.666020	2422.671390	2850.527340	2570.150880	2740.080320
-400.00	1927.554320	1916.025150	1697.078740	1680.351930	1785.884030	2144.215330	2233.783940	2000.831540	2256.404540
-450.00	1565.836670	1393.225710	1380.827760	1462.712650	1614.080200	1901.646360	1773.360350	1697.070680	1891.475460
-500.00	1167.969360	1156.791020	1220.509890	1279.438600	1466.970830	1576.769040	1424.329590	1457.981200	1609.395870

4782

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 25

MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QJ1P3SQ2 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)								
	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00
500.00	2534.482420	2531.678220	2581.539310	3103.647220	3821.905030	3635.429930	3535.159420	3467.338380	3549.940190
450.00	3074.890630	3063.036130	3108.119870	4175.833500	4545.299320	4259.934570	4183.104980	4296.288570	4573.959470
400.00	3808.224610	3779.161620	4310.424800	5657.668950	5451.488770	5155.327640	5317.572750	5677.825200	5270.402340
350.00	4836.578610	4774.318360	6238.346190	7209.050290	6590.025880	6769.919920	7249.852050	6645.669430	5555.279300
300.00	6339.453130	6690.294430	9131.402340	9066.755860	8939.778320	9598.790040	8652.698240	7055.693850	6040.142580
250.00	8687.131840	10915.632800	13134.074200	12719.443400	13337.168000	11746.722700	9269.949220	7730.523440	6998.670900
200.00	12781.238300	18302.377000	20089.916000	19879.265600	16876.890600	12973.957000	11209.661100	9881.086910	8708.812500
150.00	27057.068400	36421.390600	34338.410200	28133.503900	21364.298800	17262.085900	14157.920900	10726.423800	8283.867190
100.00	61174.339800	84140.023400	57695.210900	38497.875000	26121.535200	18001.421900	12883.313500	9593.996090	7849.168950
50.00	0.000000168507	1.88000	82367.242200	43449.253900	26959.418000	18700.759800	14196.167000	11147.035200	8986.912110
0.00	0.000000106175	0.094000	69572.867200	38623.371100	24801.724600	16922.312500	12935.281300	10218.779300	8282.504880
-50.00	48101.960900	56096.683600	41709.074200	28475.316400	20854.298800	14861.904300	10972.385700	8328.237300	6721.992680
-100.00	22292.418000	25497.726600	23726.476600	19295.660200	15183.241200	12385.339800	10669.857400	8624.417970	6830.130370
-150.00	11578.679700	14284.595700	14417.743200	13669.146500	12170.515600	9123.808590	7730.896970	7055.030270	6379.303220
-200.00	8070.962890	8895.987300	10425.480500	9118.663090	9247.014650	8472.552730	6633.722660	5426.901370	4821.017090
-250.00	5943.644530	5741.742190	7279.189940	7091.721190	6336.654300	6683.990230	6238.370610	5043.399410	4240.757320
-300.00	4558.223140	4346.766600	5128.957520	5828.504880	5073.159180	4810.091310	5063.193850	4788.256350	3967.262700
-350.00	3602.858640	3458.873780	3673.953610	4600.327640	4329.594730	3902.379640	3782.852290	3973.546880	3794.472170
-400.00	2917.668700	2815.656010	2816.002200	3480.245610	3715.924320	3317.336430	3149.040280	3058.105960	3205.705570
-450.00	2410.350100	2335.634770	2348.585690	2660.292480	3188.550050	2918.721190	2720.075200	2597.603270	2527.272220
-500.00	2024.611210	1968.363530	1987.257810	2056.266360	2528.360110	2577.090090	2361.991460	2279.663330	2184.097410

0294

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***07/16/93
15:11:18
PAGE 26

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QUIP3SQ2 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	400.00	450.00	500.00	X-COORD (METERS)
---------------------	--------	--------	--------	------------------

500.00	3770.174800	3565.920410	3134.364990	
450.00	4287.089360	3713.371340	3341.960450	
400.00	4492.437990	3985.152590	3607.461430	
350.00	4851.567870	4332.143550	3879.779050	
300.00	5304.920900	4785.797850	4455.521480	
250.00	6378.175780	5799.322750	5113.054690	
200.00	7141.080570	5786.670900	4741.590330	
150.00	6506.550290	5439.053710	4687.930180	
100.00	6542.666990	5539.407710	4752.792970	
50.00	7402.402830	6205.957030	5280.691890	
0.00	6854.308110	5770.535160	4928.614750	
-50.00	5661.822270	4837.287110	4183.519530	
-100.00	5497.533690	4534.680180	3950.550050	
-150.00	5629.431150	4660.410640	3899.052000	
-200.00	4531.963380	4219.341800	3909.958500	
-250.00	3749.081050	3326.248050	3151.599610	
-300.00	3406.911870	3059.882080	2754.375490	
-350.00	3205.597170	2798.970950	2548.798830	
-400.00	3083.918460	2649.293460	2351.022710	
-450.00	2646.833500	2566.418460	2238.155030	
-500.00	2134.172850	2233.829830	2177.031250	

4787

*** ISCLT2 - VERSION 93109 *** *** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
 *** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93
 15:11:18
 PAGE 27

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OU1P3SQ2 ***

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
-1825.00	-2865.00	82.749596	-3460.00	3870.00	36.364010
4722.00	1960.00	149.035629	6470.00	-4590.00	54.635479
5500.00	3460.00	101.569771	5000.00	2390.00	130.485870

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 28

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QU1P3SQ3 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)								
	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00
500.00	1420.403200	1715.777220	1903.960080	1844.079100	1859.288820	2145.840580	2748.999020	2922.573490	2850.233150
450.00	1554.023800	1846.180420	2218.801030	2199.343510	2120.713130	2475.907960	3213.802490	3421.714600	3322.918700
400.00	1748.984990	1978.462280	2440.924800	2648.640140	2543.136720	2890.547850	3807.794430	4059.660890	3921.752690
350.00	2113.263920	2138.343510	2684.355220	3223.623050	3141.725590	3421.448000	4583.065920	4892.004390	4774.671880
300.00	2781.133540	2644.150150	2942.384770	3727.366460	3937.974610	4188.548340	5620.764160	6004.784670	6724.436040
250.00	3573.510990	3585.417240	3465.380130	4235.746580	5017.206050	5461.475100	7051.750490	7536.137210	9532.043950
200.00	3940.580320	4730.129390	4797.599610	5209.639650	6312.542480	7300.157230	9099.381840	10973.844700	13666.472700
150.00	4455.220210	5296.421880	6543.168950	7084.789060	8212.464840	10068.093800	12804.727500	17187.156300	19935.054700
100.00	6417.216310	7139.079590	8266.804690	9609.296880	11941.832000	15622.592800	20380.117200	27711.621100	32639.168000
50.00	8082.855470	9996.150390	11846.314500	14866.681600	19821.763700	25990.482400	42088.988300	57387.015600	56321.886700
0.00	9357.951170	12137.082000	16250.636700	23231.384800	33783.460900	47172.144500	52645.339800	111975.664000	103089.930000
-50.00	12102.545900	15516.211900	21141.789100	31104.130900	51721.378900	79556.226600	0.000000	0.000000	146008.234000
-100.00	12338.129900	16268.148400	22445.451200	32468.119100	53144.050800	86787.007800	0.000000	103454.555000	112444.945000
-150.00	12040.923800	15708.489300	21061.560500	27451.677700	36622.726600	53636.136700	72212.234400	70809.820300	65418.921900
-200.00	12159.854500	13684.076200	16100.439500	19143.531300	22346.324200	26888.980500	29977.527300	35332.921900	34456.843800
-250.00	9056.059570	10085.680700	11451.483400	12878.629900	14035.970700	14233.482400	16773.337900	20230.197300	21671.068400
-300.00	6965.159180	8100.313960	8831.894530	8790.858400	8519.339840	9885.546880	11248.373000	13138.405300	14447.655300
-350.00	6010.244140	6420.655270	5992.714840	5711.789550	6944.252440	7113.926760	8228.544920	8819.635740	10203.837900
-400.00	4869.045410	4524.515140	3997.863280	4912.716310	5282.957520	5257.585940	6440.771480	6670.670900	7344.143550
-450.00	3537.383540	3042.954590	3564.055420	4245.455080	4087.621830	4012.588380	5173.341800	5361.385250	5365.652830
-500.00	2470.665530	2659.254150	3174.885740	3496.170900	3210.373050	3341.670900	4244.022950	4399.030270	4111.018550

0297

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 29

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QU1P3SQ3 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00
500.00	2962.510990	3679.702390	4378.255860	4214.678220	4041.114500	4003.313720	3929.484380	4127.610840	4331.171390
450.00	3674.940190	4669.216800	5057.984380	4806.007320	4657.179200	4564.752930	4814.368650	5059.018070	4935.085450
400.00	4855.312010	5953.158690	5871.745610	5506.522460	5395.289550	5708.025880	6000.018070	5822.372560	5142.138180
350.00	6443.875000	7306.562990	6856.105960	6488.526860	6904.918950	7264.135250	6997.824710	6096.422360	5318.002440
300.00	8612.647460	8745.299800	8047.718750	8539.052730	8992.541020	8597.004880	7378.604980	6331.882810	5737.688960
250.00	11465.031300	10556.522500	10855.367200	11438.183600	10825.719700	9126.701170	7694.310550	6879.618650	6168.851560
200.00	14360.196300	14612.562500	15060.273400	14061.498000	11590.301800	9555.961910	8537.033200	7928.417970	7334.593750
150.00	21035.683600	20753.554700	19011.959000	15216.250000	12738.271500	11571.379900	10473.018600	9476.017580	8375.642580
100.00	31551.394500	27329.033200	22523.330100	18431.685500	16133.443400	14155.351600	11706.044900	9552.501950	7877.509280
50.00	47612.500000	36201.355500	27847.398400	22928.668000	17575.738300	13715.189500	10872.970700	8740.730470	7444.699710
0.00	67227.750000	44278.722700	31054.894500	22572.078100	16858.822300	13042.781300	10864.329100	9191.258790	7879.442380
-50.00	76433.367200	46286.113300	31297.375000	23172.892600	18262.959000	14759.911100	12176.768600	10218.585900	8699.768550
-100.00	65076.273400	41588.429700	29025.408200	21141.982400	16409.572300	13342.750000	11066.960000	9332.021480	7979.434570
-150.00	44883.910200	32656.873000	24096.152300	18110.439500	13945.002000	10963.342800	8858.299800	7589.170410	6578.145020
-200.00	31461.224600	24914.716800	19747.996100	16467.835900	14103.797900	11290.978500	9171.361330	7547.709960	6285.196290
-250.00	20782.304700	19040.705100	14964.480500	12620.561500	11081.486300	10009.098600	9024.513670	7704.092770	6485.790530
-300.00	14225.933600	13714.845700	13424.820300	10840.949200	8659.021480	7694.485840	7200.375980	6686.237790	6186.509770
-350.00	10905.731400	9938.043950	9998.290040	9966.626950	8263.540040	6781.928220	5831.344240	5290.566410	5041.791020
-400.00	8758.475590	7970.026860	7314.984860	7659.625490	7692.022460	6509.843750	5457.696780	4774.646000	4310.663090
-450.00	6640.713380	6791.171880	6028.158200	5799.605960	6061.659670	6118.336910	5263.843260	4489.406740	3990.251460
-500.00	5093.359860	5828.125980	5272.954100	4779.804690	4717.002440	4921.632320	4985.290530	4353.466800	3776.439700

0298

4783

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 30

MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: Q01P3SQ3 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	400.00	450.00	500.00	X-COORD (METERS)
---------------------	--------	--------	--------	------------------

500.00	4240.606930	3814.908200	3431.752200	
450.00	4402.226560	3926.646240	3656.557860	
400.00	4541.271480	4199.572750	3887.030270	
350.00	4877.132320	4478.713380	4119.781250	
300.00	5219.376950	4758.967770	4431.149900	
250.00	5783.126950	5445.664550	5118.760740	
200.00	6780.668950	6278.413090	5466.308110	
150.00	7051.265630	5993.747560	5135.065920	
100.00	6558.531250	5616.255370	5013.630860	
50.00	6491.954590	5715.572750	5086.288090	
0.00	6832.134280	5985.761230	5303.604980	
-50.00	7498.405270	6535.445800	5761.752440	
-100.00	6904.550780	6039.400880	5342.832520	
-150.00	5759.669430	5090.412110	4548.311040	
-200.00	5474.292970	4864.042480	4364.241210	
-250.00	5508.881350	4726.907710	4151.006840	
-300.00	5597.375000	4846.718750	4227.738770	
-350.00	4775.490720	4511.569820	4254.555660	
-400.00	3914.093510	3748.516850	3603.017820	
-450.00	3654.739750	3352.860600	3081.905030	
-500.00	3399.271480	3140.842770	2905.236570	

0299

4782

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 31

* MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OU1P3SQ3 ***

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
-1825.00	-2865.00	139.647614	-3460.00	3870.00	57.795097
4722.00	1960.00	231.344284	6470.00	-4590.00	86.485023
5500.00	3460.00	155.594269	5000.00	2390.00	198.596542

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 32

* MODELING OPTIONS USED: CONC RURAL FLAT DEFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QUTP3SQ4 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00
500.00	1060.159910	1129.189940	1238.606200	1515.075680	1595.251220	1530.955200	1633.338620	2064.083010	2482.966060
450.00	1214.345210	1266.825680	1355.693600	1645.442630	1914.462520	1846.006710	1887.615480	2426.654050	2945.132320
400.00	1565.538090	1474.966920	1543.509890	1780.100460	2228.349610	2271.998290	2207.845210	2895.877690	3549.100340
350.00	1944.923950	1949.186650	1832.081050	1923.507320	2486.649900	2834.698970	2700.281010	3518.116940	4358.480960
300.00	2106.954350	2472.307620	2495.730220	2340.066410	2768.569820	3571.177490	3495.508060	4367.574220	5476.160640
250.00	2266.107910	2707.828370	3247.020260	3311.803710	3197.060300	4158.496580	4626.096190	5580.219730	7077.139160
200.00	2737.755370	2935.036130	3606.208740	4448.728030	4606.577150	5078.325680	6283.026370	7873.087890	9491.820310
150.00	3917.929930	4195.415530	4399.075200	5031.239260	6451.291500	7331.413090	8614.073240	11670.835900	15707.377900
100.00	4566.071290	5612.040040	6594.059080	7400.030760	8947.009770	10594.720700	13662.171900	19165.566400	29563.816400
50.00	4683.841800	5846.548830	7472.259770	9806.149410	13060.485400	17556.214800	26114.265600	41966.281300	73854.875000
0.00	6272.874020	7745.766600	9814.041020	13129.524400	18742.197300	28406.386700	52263.918000	63819.402300	0.000000
-50.00	7176.647460	8929.440430	11409.346700	15083.364300	21908.523400	34155.804700	63688.437500	90798.578100	0.000000
-100.00	6619.747070	8262.181640	10855.699200	14697.958000	20723.603500	29476.189500	42979.453100	67094.882800	66661.632800
-150.00	6934.113770	8756.570310	11283.688500	12998.201200	15596.975600	19036.103500	22290.621100	27516.689500	32494.972700
-200.00	6899.822750	7548.513670	8182.315920	9130.408200	10771.958000	12017.443900	12653.960900	14302.584000	17160.316400
-250.00	5195.560550	5381.449710	6197.054200	7299.117190	7641.559080	7489.790040	8170.052250	9297.236330	10244.778300
-300.00	4078.468990	4585.542480	5250.500980	5385.820800	4803.276370	5331.354980	5819.818850	6342.978520	7529.334470
-350.00	3521.764650	3948.608640	3994.220460	3553.736820	3621.129390	4471.587890	4258.449710	4787.903810	5765.378910
-400.00	3073.258540	3078.422610	2747.472900	2620.196290	3170.207280	3547.717290	3185.209230	3816.277100	4549.839840
-450.00	2444.950440	2189.842040	2097.782230	2319.186280	2779.992920	2770.513180	2491.861330	3113.202880	3678.792480
-500.00	1788.172360	1718.913820	1821.526120	2093.073000	2392.158690	2193.109130	2107.127930	2588.551760	3034.516110

0301

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 33

* MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: 0U1P3S04 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00
500.00	2440.489750	2513.260250	2901.882320	3604.749760	3586.225830	3445.696530	3411.204590	3345.536380	3494.856200
450.00	2884.667480	2960.816650	3797.454100	4359.948730	4137.425290	4023.326420	3938.760250	4123.560550	4346.865230
400.00	3460.838620	3830.046880	4993.758790	5137.103520	4821.030760	4721.560550	4966.043950	5235.874020	4879.269530
350.00	4225.569820	5315.150880	6514.830570	6096.787600	5773.609860	6108.353520	6448.947270	5952.183590	5109.458980
300.00	5405.722660	7429.986330	7970.896000	7283.098140	7714.228520	8151.810550	7432.126950	6267.665530	5459.241210
250.00	8203.916020	10503.965800	9860.960940	10076.909200	10649.027300	9554.542970	7879.487790	6734.524410	5950.513180
200.00	12625.042000	13977.176800	14039.136700	14524.489300	12751.673800	10215.256800	8520.282230	7772.748540	7116.326660
150.00	19955.726600	21483.021500	21022.988300	17886.185500	14066.479500	12137.627900	10788.403300	9583.157230	8174.362300
100.00	37076.964800	34514.980500	28641.812500	22335.763700	18204.085900	15466.864300	12094.870100	9494.486330	7564.450200
50.00	75972.312500	54519.937500	38358.101600	27767.554700	19803.554700	14556.301800	10961.323200	8735.460940	7345.820800
0.00	140161.109000	76013.515600	44214.625000	28796.824200	19722.644500	15153.868200	12079.122100	9855.779300	8197.486330
-50.00	136049.328000	74161.726600	41452.582000	27333.148400	19678.302700	15200.087900	12096.658200	9858.998050	8193.545900
-100.00	75062.328100	48735.765600	33149.054700	22675.822300	16342.331100	12179.335000	9392.123050	7807.116700	6597.021970
-150.00	35163.203100	30636.943400	23923.476600	18281.615200	15161.142600	12253.543900	9583.639650	7630.733400	6172.904300
-200.00	19229.050800	19189.267600	17499.931600	13544.766600	11094.930700	9810.461910	8773.531250	7766.993650	6377.285640
-250.00	12381.636700	12388.002900	12039.424800	11855.398400	9570.663090	7469.146970	6588.959960	6145.057620	5678.345210
-300.00	8251.268550	9787.045900	8402.479490	8483.581050	8562.178710	7121.630860	5741.880370	4966.535160	4410.021970
-350.00	5638.697750	7053.621580	6975.428710	6015.773440	6374.451660	6475.340330	5509.055660	4554.161130	4012.609620
-400.00	4260.322750	5159.903810	5841.253420	5168.864260	4716.265630	4972.193360	5071.686040	4391.895510	3703.254150
-450.00	3471.814210	3825.224850	4672.528810	4464.392090	4016.271730	3802.013430	3992.411870	4082.990720	3586.344730
-500.00	2881.693360	2924.956540	3622.016110	3876.046390	3499.665280	3299.718750	3134.347410	3280.543460	3365.406010

0302

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***07/16/93
15:11:18
PAGE 34

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: 0J1P3S04 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	400.00	450.00	500.00	X-COORD (METERS)
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500.00	3679.204350	3483.705320	3107.530520	
450.00	4089.179440	3611.667480	3272.302980	
400.00	4254.984380	3817.118900	3508.371580	
350.00	4517.696290	4110.450200	3748.544680	
300.00	4897.281250	4407.283690	3992.053220	
250.00	5403.884280	5044.417480	4704.014160	
200.00	6500.374510	5911.987790	4996.573240	
150.00	6697.626950	5542.690430	4629.191410	
100.00	6136.407710	5321.523930	4658.991700	
50.00	6264.887700	5408.067380	4717.577640	
0.00	6928.102540	5935.168950	5143.856450	
-50.00	6920.733400	5926.307130	5134.547360	
-100.00	5652.195310	4900.299800	4291.970210	
-150.00	5253.242680	4587.030760	4041.478520	
-200.00	5296.261720	4444.728030	3816.045650	
-250.00	5225.672850	4553.182620	3897.134770	
-300.00	4199.022460	3962.656740	3728.546880	
-350.00	3599.676760	3239.761720	3060.015380	
-400.00	3310.680180	3013.806640	2752.099610	
-450.00	3076.972410	2792.204590	2570.045410	
-500.00	2997.655760	2611.051270	2391.688720	

1383

4782

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

PAGE 35

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: 0U1P3S04 ***

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
-1825.00	-2865.00	103.411789	-3460.00	3870.00	43.656902
4722.00	1960.00	178.468445	6470.00	-4590.00	65.869919
5500.00	3460.00	119.997688	5000.00	2390.00	153.721909

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 36

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OUIP3SQ5 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)								
	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00
500.00	456.699677	491.239960	526.407532	560.166809	643.166626	721.127930	719.939453	777.389832	846.512878
450.00	578.456116	547.632813	593.535828	639.067749	686.236084	877.485962	835.800598	906.557373	996.851807
400.00	675.385498	710.825684	670.989990	732.581177	792.751343	967.929443	1049.277340	1071.657350	1192.853880
350.00	730.370178	843.263977	896.003601	843.123413	928.377014	1061.038820	1338.731930	1287.246950	1455.359380
300.00	847.470337	920.136597	1083.997440	1166.527100	1093.949460	1216.395510	1614.877080	1673.167240	1818.570190
250.00	976.823730	1082.016480	1195.936650	1446.647220	1584.402340	1480.313600	1853.282960	2299.873780	2342.431400
200.00	1230.048580	1261.090450	1428.512940	1618.234380	2029.185670	2279.670410	2121.010990	3193.797610	3245.427490
150.00	1587.736570	1864.463750	1988.249390	2054.604250	2310.048830	3052.777830	3580.317380	4029.022220	5165.814450
100.00	1683.770510	2008.201290	2512.905030	3211.542970	3712.630620	4077.442870	5120.711910	6726.832520	8903.305660
50.00	1868.692140	2231.722660	2715.664790	3380.684570	4563.402830	6485.114260	9053.407230	13063.851600	20056.244100
0.00	2372.067380	2899.010990	3628.908690	4681.756840	6294.914550	8953.493160	14153.170900	26011.740200	63355.710900
-50.00	2517.481450	3085.328610	3872.859860	5009.073730	6745.501950	9704.230470	15912.387700	29490.679700	63251.863300
-100.00	2492.900390	3036.156250	3777.719240	4964.326660	6897.275390	9893.276370	12237.858400	16396.371100	21083.335900
-150.00	2498.846440	3138.648190	4022.724370	4866.979490	5398.263670	5865.028320	7727.253420	8264.333980	8829.588870
-200.00	2652.060060	2894.454830	3079.425290	3312.687990	3748.812740	4591.340330	4460.793460	4677.877930	5045.251460
-250.00	1997.152950	2168.027340	2371.619870	2595.715090	3042.048340	2889.061520	2649.385990	3542.047120	3098.837890
-300.00	1657.479980	1775.309200	1898.489500	2159.426760	2031.270020	1849.362300	2232.645020	2430.837160	2310.012700
-350.00	1375.959470	1447.122560	1610.798460	1507.882450	1384.474120	1500.431400	1882.102910	1722.284790	1794.149540
-400.00	1139.082760	1247.505250	1165.334230	1077.185300	1160.500610	1303.919310	1471.970090	1337.803100	1435.316650
-450.00	994.909180	928.884766	863.439392	924.987854	980.197937	1152.077390	1126.626950	1107.479980	1175.606200
-500.00	758.743164	708.669067	755.308533	798.481262	854.088684	990.937012	890.475952	932.260498	981.568115

0305

4782

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

PAGE 37

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OUIP3SQ5 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)								
	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00
500.00	1124.091800	1127.516110	1204.293950	1253.463990	1616.578250	1626.591800	1626.415280	1619.206180	1589.737790
450.00	1349.401980	1349.989620	1439.666140	1640.357420	1996.829960	1926.275880	1927.287110	1893.584470	1864.850830
400.00	1650.840700	1645.510620	1749.710570	2261.769290	2386.941410	2334.538570	2297.874020	2261.940190	2447.448730
350.00	2066.768800	2049.445070	2271.574460	3077.974370	2886.990230	2852.869380	2808.131590	3056.285160	2719.820310
300.00	2662.681640	2620.436280	3417.373540	3854.527830	3644.193120	3590.240480	3934.035890	3441.513180	2924.831300
250.00	3559.933840	3462.444340	5197.170900	4893.148930	4770.164060	5267.826170	4504.741700	3732.689210	3251.217530
200.00	5022.078610	5858.232910	7289.852540	6678.905270	7441.247560	6166.397950	4937.382810	4190.402340	3603.997560
150.00	7585.052730	10564.778300	10548.387700	11395.166000	8980.502930	6846.136720	5850.591800	5186.871580	4579.252440
100.00	14629.275400	19681.002000	19769.109400	14425.818400	11170.866200	9285.065430	7319.588380	5429.246580	4116.251460
50.00	43191.308600	47572.535200	31701.097700	21212.207000	13756.536100	9122.655270	6552.109380	5193.229980	4218.550780
0.00	0.000000	104583.375000	41234.734400	21671.646500	13936.391600	9915.192380	7440.518070	5797.378910	4648.468260
-50.00	73213.484400	75589.125000	34275.937500	19119.158200	11872.601600	8588.057620	6530.406250	5143.432620	4161.740720
-100.00	27805.566400	28175.996100	21141.214800	14510.021500	11109.426800	7711.158200	5576.195800	4380.021970	3609.674070
-150.00	11160.834000	13767.227500	12587.575200	10196.394500	7216.729490	6389.724610	5564.471190	4413.939450	3454.889160
-200.00	6641.893550	7770.891110	7470.175780	7440.468750	6380.898930	4708.792480	3908.606200	3567.750000	3266.375000
-250.00	4484.620120	4561.311040	5634.660160	4679.352050	4937.813480	4386.752930	3404.379390	2922.418950	2520.652340
-300.00	3226.086670	3020.705320	4035.075200	3729.859860	3359.318600	3529.196290	3206.029050	2579.378170	2268.291020
-350.00	2436.037350	2310.956540	2755.917240	3060.815920	2718.282710	2535.169430	2654.046390	2449.569580	2024.880130
-400.00	1903.765870	1823.063480	1922.490840	2504.564700	2240.923100	2117.687740	1985.847290	2072.795170	1935.716920
-450.00	1528.707890	1474.193480	1561.693850	1857.780030	1924.625610	1781.774050	1698.560300	1600.920170	1666.705930
-500.00	1254.818850	1216.569820	1292.260860	1393.133060	1662.665890	1510.770870	1460.264160	1394.580320	1320.395510

030680

4787

*** ISCLT2 - VERSION 93109 *** *** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
 *** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93
 15:11:18
 PAGE 38

MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QUTP3S05 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	400.00	450.00	500.00	X-COORD (METERS)
500.00	1569.029540	1684.086060	1551.556030	
450.00	2007.415530	1832.418210	1635.988770	
400.00	2207.283450	1942.431270	1774.411250	
350.00	2356.947270	2124.460450	1917.476320	
300.00	2597.323970	2311.896730	2064.469480	
250.00	2843.058590	2498.396480	2293.481690	
200.00	3306.105710	3018.296140	2592.149170	
150.00	3616.047360	2894.670410	2424.649410	
100.00	3419.716800	2899.915280	2490.587650	
50.00	3496.837160	2947.580080	2520.044920	
0.00	3813.942380	3188.478760	2707.551030	
-50.00	3441.209470	2896.268550	2473.919190	
-100.00	3028.454100	2579.123050	2224.647950	
-150.00	2797.068850	2406.497070	2092.665040	
-200.00	2864.235350	2353.678470	1956.389770	
-250.00	2270.780520	2139.627200	1998.923950	
-300.00	1999.668090	1769.438480	1572.542480	
-350.00	1813.025270	1625.255980	1460.257690	
-400.00	1634.243290	1483.693970	1348.247190	
-450.00	1570.557250	1349.133060	1241.489620	
-500.00	1372.178470	1305.090580	1139.510740	

0307

4788

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

PAGE 39

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OJ1P3SQ5 ***

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
-1825.00	-2865.00	44.214363	-3460.00	3870.00	18.778198
4722.00	1960.00	78.008347	6470.00	-4590.00	28.607359
5500.00	3460.00	52.487434	5000.00	2390.00	67.478531

0308

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***07/16/93
15:11:18
PAGE 40

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QJ1P1T4 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00
500.00	1597.383060	1777.506840	1798.424680	1731.045900	1671.060550	1783.752080	2131.701900	2559.415530	2581.854000
450.00	1673.934080	1884.827640	2118.899170	2156.632570	2080.339600	2006.669920	2287.324710	2818.469240	3107.420650
400.00	1825.967900	1982.740600	2262.521970	2579.398930	2645.064450	2554.048100	2456.547850	3103.056640	3779.298100
350.00	2020.558720	2175.122310	2396.001950	2778.692870	3213.287600	3321.588130	3213.023930	3405.777100	4309.363280
300.00	2470.653560	2491.416260	2649.406250	2958.926030	3493.272710	4111.574710	4295.633300	4265.174800	4902.620610
250.00	3170.410160	3326.676760	3459.277830	3541.781490	3743.920170	4520.546880	5441.395510	5768.307130	6405.337890
200.00	3534.928960	4073.920900	4539.325200	4868.261720	5178.448240	5543.974610	6162.896970	7522.955570	8589.667970
150.00	3620.250980	4209.654300	4942.518550	5864.947750	6972.310060	7728.277830	8706.993160	10281.677700	11901.383800
100.00	3819.147950	4345.396970	5047.399410	6057.750980	7377.237790	9135.302730	11529.166000	14158.574200	18030.664100
50.00	4655.962400	5372.361330	6272.478520	7425.256840	8934.988280	11295.240200	14674.235400	19694.671900	28119.976600
0.00	5659.108400	6592.958500	7780.185060	9320.532230	11367.402300	14166.876000	18131.091800	24578.044900	36893.027300
-50.00	5512.168950	6406.738280	7539.144530	9000.745120	10930.438500	13826.648400	18240.349600	24849.851600	35676.820300
-100.00	5230.035640	6045.413570	7066.613770	8633.851560	10728.585000	13577.093800	17547.189500	22492.652300	28453.214800
-150.00	5297.560060	6269.820310	7501.106450	9082.825200	11146.516600	12795.557600	14361.580100	16929.265600	19756.943400
-200.00	5552.678710	6522.082030	7628.086430	8256.722660	8901.144530	9576.732420	10721.213900	12261.638700	13520.891600
-250.00	5430.150390	5761.872560	6083.515140	6366.838870	6608.192380	7597.027830	8763.678710	9187.857420	9283.675780
-300.00	4428.013670	4570.562500	4747.621090	5126.666990	5806.133790	6553.166020	6757.088870	6311.345210	6212.698240
-350.00	3630.812990	3851.136960	4104.756350	4572.203130	5074.444820	5170.082520	4780.615230	4414.335450	5349.485350
-400.00	3189.973390	3358.541750	3688.842290	4040.080570	4079.913090	3768.537350	3290.894040	3929.655760	4631.447270
-450.00	2802.713130	3042.206050	3292.083250	3300.340330	3048.382810	2687.365970	2962.360840	3499.933350	3762.218990
-500.00	2553.802490	2738.748540	2729.183350	2519.799560	2237.616210	2365.871580	2700.692630	3124.746340	3064.702390

0309

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 41

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OUIPIT4 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)								
	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00
500.00	2463.107910	2934.439210	3767.904790	3991.932130	3874.495850	4487.848630	5572.403320	5878.774900	5569.716800
450.00	3001.948490	3434.946780	4470.723630	4741.240720	4577.365720	5885.101560	7073.009770	6819.724610	6371.726560
400.00	3705.925540	4078.107180	5389.442380	5719.866210	6000.282710	7758.730470	8510.227540	7955.515140	7623.595210
350.00	4641.261720	5136.616210	6621.211430	7029.687500	8348.979490	10306.920900	10174.546900	9507.554690	10280.001000
300.00	5907.230470	6696.063480	8322.874020	9159.980470	11713.640600	13387.237300	12524.160200	13145.737300	13595.761700
250.00	7309.550780	8950.300780	10957.118200	13865.534200	16643.023400	17134.900400	17819.789100	17956.570300	15958.487300
200.00	10106.447300	12354.608400	15523.576200	21412.939500	24746.013700	25810.716800	24829.324200	21542.685500	17749.789100
150.00	14450.194300	19985.357400	27233.929700	35336.117200	40674.914100	37878.710900	32710.308600	26599.316400	21686.248000
100.00	24678.119100	35834.371100	56288.796900	74784.007800	72494.437500	56226.781300	42203.281300	32401.146500	25219.808600
50.00	43294.968800	56589.168000	40046.140600	127051.836000	123501.680000	79098.382800	49974.582000	35116.675800	25576.871100
0.00	59920.367200	89247.398400	0.000000	0.000000	148834.719000	85866.578100	52969.250000	34662.523400	26242.410200
-50.00	57049.226600	74891.281300	17643.533200	96022.171900	110917.414000	69749.703100	44506.785200	31583.220700	23296.002000
-100.00	37776.261700	52433.023400	67852.335900	67101.046900	64151.781300	46422.718800	34553.449200	26482.873000	20153.787100
-150.00	22416.591800	27346.662100	30055.085900	34732.207000	35046.726600	31561.474600	26215.082000	21168.990200	17372.357400
-200.00	14458.696300	14881.332000	17211.492200	20659.722700	22427.359400	21551.759800	19705.369100	16200.734400	13674.562500
-250.00	9091.399410	10518.334000	11804.164100	13739.145500	15083.570300	14923.284200	14511.131800	14093.762700	11926.004900
-300.00	7297.390630	7677.504390	8734.122070	9410.366210	10809.835000	11632.990200	10598.119100	10559.527300	10574.914100
-350.00	5604.524900	5742.883790	6902.856930	7116.942380	7884.903320	9248.183590	8609.387700	7845.896000	8166.149410
-400.00	4373.425290	4410.782230	5587.250980	5764.998050	5833.064450	7077.686040	7361.014160	6575.700680	6216.844730
-450.00	3461.104250	3688.849850	4612.207520	4760.524900	4465.773440	5475.453610	6319.926270	5762.657230	5178.308590
-500.00	2773.404790	3131.372800	3870.449460	3995.070310	3773.124270	4274.547850	5053.566410	5070.502440	4608.927730

0310

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
 *** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93
 15:11:18
 PAGE 42

MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OUIPIT4 ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	400.00	450.00	500.00	X-COORD (METERS)
---------------------	--------	--------	--------	------------------

500.00	5374.580080	5327.688960	5722.786130	
450.00	6316.098630	6810.267090	7077.514650	
400.00	8272.254880	8588.824220	7958.961910	
350.00	10659.115200	9773.420900	8378.008790	
300.00	12298.805700	10353.277300	8752.372070	
250.00	13130.196300	10901.155300	10101.192400	
200.00	15119.486300	13607.547900	12234.690400	
150.00	18831.152300	16081.333000	12978.520500	
100.00	19349.986300	15115.808600	11996.372100	
50.00	19145.093800	15064.630900	12542.554700	
0.00	20741.013700	16798.185500	13880.384800	
-50.00	17699.652300	14338.151400	11951.002000	
-100.00	15675.906300	12427.027300	10017.218800	
-150.00	15180.734400	12647.860400	10342.653300	
-200.00	11779.089800	10712.796900	9714.120120	
-250.00	9638.666990	8232.464840	7746.767580	
-300.00	9144.031250	7574.803710	6379.658690	
-350.00	8228.330080	7235.354980	6111.945310	
-400.00	6509.953610	6587.315430	5870.457030	
-450.00	5088.426270	5316.503910	5396.870610	
-500.00	4319.526370	4247.408690	4438.145020	

0311

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 43

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QU1P1T4 ***

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
-1825.00	-2865.00	148.863617	-3460.00	3870.00	63.720905
4722.00	1960.00	279.756622	6470.00	-4590.00	100.523552
5500.00	3460.00	186.053604	5000.00	2390.00	240.387207

0312

4782

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 44

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QJ1BPIT ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)								
	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00
500.00	496.777985	479.557434	482.647308	520.051392	556.761780	596.910950	747.589111	713.928040	777.301392
450.00	525.824097	600.125000	580.616638	585.656799	634.896179	682.386536	827.336121	881.360168	909.280762
400.00	592.341187	640.742798	742.753784	719.513062	726.925415	793.460754	901.563660	1109.374150	1078.542360
350.00	676.447388	729.859924	799.729736	944.311157	917.018311	928.242188	1020.864620	1337.058590	1358.904300
300.00	768.165283	842.201538	922.090637	1027.556760	1242.353390	1211.841670	1229.345090	1517.066280	1826.137700
250.00	916.801636	964.739929	1076.736080	1201.985470	1370.375240	1709.648320	1680.779050	1708.623540	2497.698240
200.00	1200.749760	1339.270140	1396.398680	1422.633060	1630.953250	1919.974490	2502.017580	2498.000000	3068.437010
150.00	1261.995480	1481.195800	1796.005740	2188.638920	2372.073970	2486.140870	2882.544190	4023.791260	4363.667480
100.00	1398.488530	1629.230590	1923.423830	2318.214360	2980.823490	3940.186770	4835.778320	5684.080570	7479.843260
50.00	1518.959470	1787.588260	2137.569090	2606.090090	3253.843750	4188.040530	5884.599120	8953.780270	14543.238300
0.00	1998.115840	2400.885990	2941.780030	3692.131590	4775.258790	6428.425290	9154.333980	14044.519500	25449.507800
-50.00	1894.474000	2263.534180	2753.992680	3425.391110	4377.596190	5791.501460	8487.954100	13386.825200	21502.707000
-100.00	1937.133420	2306.983400	2793.238770	3488.053470	4617.977540	6302.722170	7627.821780	9021.637700	11693.091800
-150.00	1940.068970	2351.446530	2929.840090	3594.704830	3935.213130	4206.814450	4869.706050	6211.145510	5888.973140
-200.00	2034.896730	2273.257810	2408.510010	2541.697510	2824.257080	3188.095460	3819.392090	3407.364260	3772.375980
-250.00	1630.120480	1738.171020	1892.026610	2047.887700	2242.182620	2587.780030	2294.443120	2212.677000	2969.969240
-300.00	1363.648070	1458.330440	1548.755000	1659.696290	1866.133180	1655.001590	1602.658450	1890.880490	2087.949710
-350.00	1156.049680	1210.472050	1277.114750	1408.842650	1252.447630	1216.708130	1311.799680	1613.630860	1504.733520
-400.00	971.362854	1012.982120	1101.448970	982.567688	956.743225	1026.357670	1133.660520	1294.576660	1175.409420
-450.00	823.650146	885.141357	792.704285	773.263916	825.450317	872.035950	1009.261050	1001.233340	981.372375
-500.00	728.469666	654.372864	638.865234	678.885803	715.768066	755.263855	884.872070	794.159180	831.926086

0313

D-III-46

4782

*** ISCLT2 - VERSION 93109 *** *** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
 *** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93
 15:11:18
 PAGE 45

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QJ1BPIT ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00
500.00	830.602539	1120.955200	1138.058590	1220.506230	1275.528320	1633.053710	1665.326050	1661.443600	1652.249510
450.00	980.649780	1353.676510	1372.333500	1469.895260	1647.537840	2061.111080	1981.688350	1980.800420	1942.082150
400.00	1177.062990	1668.438600	1687.538210	1802.591670	2311.324950	2484.447270	2420.636230	2377.026610	2386.948000
350.00	1441.336670	2108.599120	2125.107670	2295.122070	3244.082030	3026.475830	2983.200440	3001.864500	3240.292720
300.00	1808.950070	2750.322750	2756.116210	3552.788330	4116.774410	3864.726070	3902.628420	4230.465820	3507.868900
250.00	2370.210450	3745.822020	3715.519290	5568.258790	5306.122070	5303.009280	5771.389650	4640.699710	3865.756100
200.00	3597.816410	5415.936520	6306.476560	8174.251460	7681.496090	8364.201170	6444.515140	5175.778810	4341.569340
150.00	5798.298830	8479.329100	12071.863300	12805.695300	13334.685500	9597.155270	7424.120120	6486.628910	5632.099120
100.00	10478.761700	17671.099600	26131.546900	24621.437500	17121.484400	13031.107400	10193.420900	7191.031250	5228.444820
50.00	26574.306600	56628.418000	73674.921900	39991.480500	22834.261700	13690.447300	8883.260740	6715.523440	5262.848140
0.00	60658.043000	0.000000	128679.164000	47711.234400	23910.177700	15377.474600	10711.287100	7905.175290	6086.010250
-50.00	36181.058600	50160.101600	55144.511700	30750.255900	18372.718800	11462.363300	7620.706540	5836.575200	4628.610350
-100.00	13320.614300	16695.691400	20326.500000	17722.683600	12421.473600	9686.569340	7979.395020	5802.688480	4346.215330
-150.00	6660.214360	8269.176760	10023.030300	9745.643550	9612.679690	6932.665530	5232.347170	4759.098630	4245.392580
-200.00	3983.717530	5296.637700	5524.216800	6700.187990	5741.072750	6031.243650	4643.684080	3689.212400	3113.577150
-250.00	2521.373780	3668.661130	3456.421390	4711.236820	4222.021000	3940.160640	4153.957520	3335.721680	2751.719970
-300.00	1916.055910	2694.786380	2573.689450	3118.091310	3411.641360	3009.264650	2883.502930	3039.853030	2516.543210
-350.00	1513.882200	2064.786130	1989.555910	2108.334960	2787.255860	2433.412350	2296.008540	2207.764650	2324.956540
-400.00	1227.439580	1632.569090	1583.251100	1681.312380	2029.169920	2071.109620	1914.268920	1812.653810	1748.810790
-450.00	1016.280460	1323.545900	1289.797240	1373.705320	1495.929080	1773.804440	1609.198850	1547.745120	1469.886350
-500.00	856.120300	1095.125490	1071.188230	1142.574100	1189.795170	1433.979980	1394.122680	1329.324100	1278.466190

0314

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 46

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OUIBPIT ***

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	400.00	450.00	500.00	X-COORD (METERS)
---------------------	--------	--------	--------	------------------

500.00	1619.188230	1623.494870	1734.849490	
450.00	1947.802000	2085.694090	1829.501950	
400.00	2565.934570	2217.296140	1965.479740	
350.00	2749.751220	2399.708980	2151.562260	
300.00	3000.588870	2646.753660	2341.879390	
250.00	3337.958980	2896.848140	2585.250980	
200.00	3881.182130	3511.155030	3059.530760	
150.00	4467.299320	3483.324460	2816.646000	
100.00	4147.354000	3439.035400	2898.362060	
50.00	4238.893550	3490.464600	2926.807620	
0.00	4833.774410	3935.320070	3268.853760	
-50.00	3765.540280	3127.336910	2641.795410	
-100.00	3476.391110	2919.594730	2487.738770	
-150.00	3512.945070	2807.768310	2299.232180	
-200.00	2815.849120	2613.888430	2361.360840	
-250.00	2389.023190	2083.125000	1858.989260	
-300.00	2133.608400	1891.371700	1680.737670	
-350.00	1969.558960	1704.867070	1535.504520	
-400.00	1838.716670	1586.010380	1395.310670	
-450.00	1422.397710	1492.813960	1307.507200	
-500.00	1217.832640	1182.630370	1241.680420	

0315

0315

D-III-48

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 47

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OJ18P1T ***

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
-1825.00	-2865.00	41.534149	-3460.00	3870.00	17.835642
4722.00	1960.00	75.774414	6470.00	-4590.00	27.469433
5500.00	3460.00	50.828487	5000.00	2390.00	65.545303

0316

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 48

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SGO1PT1 ***
 INCLUDING SOURCE(S): OUIPIT1 ,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00
500.00	1022.053160	1085.831300	1296.783450	1421.270020	1373.525880	1404.821170	1479.903320	1840.248540	2192.871340
450.00	1126.456670	1189.198120	1380.903080	1642.401000	1613.959470	1581.564700	1675.514650	2111.441410	2534.762210
400.00	1244.236820	1325.261230	1466.339360	1785.710330	1913.416500	1835.068970	1913.940920	2448.836430	2963.637210
350.00	1486.657590	1484.143800	1589.042360	1939.542240	2288.416750	2222.513670	2208.559080	2875.749270	3511.170170
300.00	1893.147460	1808.600340	1805.134520	2099.230470	2614.258060	2723.565920	2578.519290	3426.845460	4224.821780
250.00	2292.108150	2355.591310	2250.421630	2254.238280	2915.233150	3381.205320	3254.103760	4155.359380	5178.059080
200.00	2478.807860	2904.387210	3012.533450	2879.966800	3244.398680	4159.378420	4184.982910	5145.962400	6489.020020
150.00	2647.068120	3173.587650	3797.974610	3989.422850	3977.421880	4831.912110	5495.569340	6769.690430	8357.000000
100.00	3363.845700	3411.985110	4204.234380	5171.976070	5529.932620	6244.960940	7392.650390	9454.234380	11152.445300
50.00	4680.561040	5056.764650	5383.854000	6113.254880	7433.739750	8794.131840	10459.351600	13835.923800	19229.693400
0.00	5303.461430	6495.558590	7791.831050	8817.907230	10796.494100	13034.163100	16039.861300	23522.396500	35688.414100
-50.00	5446.415530	6776.837890	8614.766600	11232.133800	15130.850600	20508.462900	30679.814500	50881.703100	69648.992200
-100.00	7425.901370	9140.899410	11532.711900	15379.068400	21684.128900	32330.960900	59292.718800	69052.421900	0.000000
-150.00	8266.471680	10228.296900	12975.816400	17254.029300	24718.720700	37845.773400	68602.625000	91156.015600	0.000000
-200.00	7639.341800	9632.005860	12539.340800	16782.572300	23299.744100	32608.550800	47137.531300	71701.125000	70976.671900
-250.00	8014.775390	10048.896500	12781.612300	14587.514600	17615.355500	21410.755900	25055.091800	31296.021500	36285.914100
-300.00	7878.349610	8614.426760	9346.405270	10570.973600	12161.930700	13752.050800	14661.638700	16121.943400	19757.822300
-350.00	5999.276860	6239.097660	7118.969240	8350.208980	8783.257810	8864.635740	9236.916020	10716.000000	11811.610400
-400.00	4675.613770	5307.591800	6061.793950	6250.409180	5775.867190	6070.785640	6683.561520	7451.470700	8617.325200
-450.00	4099.411130	4589.239260	4666.700680	4226.924800	4176.278320	5113.969240	4954.343750	5488.094240	6648.625000
-500.00	3589.748290	3614.202880	3276.233400	3001.195070	3662.055180	4119.696290	3748.172850	4399.703610	5277.515140

0317

D-III-50

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 49

* MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SG0U1PT1 ***
 INCLUDING SOURCE(S): OUIP1T1 ,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00
500.00	2168.730710	2206.352290	2285.385990	2734.104740	3259.722410	3176.398930	3079.542720	3070.087400	3033.366460
450.00	2501.764890	2539.222410	2692.464600	3415.736570	3737.190670	3581.176510	3515.577640	3476.373290	3408.577150
400.00	2917.691410	2952.259030	3491.406980	4287.690920	4285.750490	4075.094240	4029.011470	3948.209720	4193.344730
350.00	3445.843260	3472.513670	4541.077640	5207.167480	4940.697270	4749.755370	4644.810550	4949.848140	5188.788570
300.00	4129.672850	4628.812990	5936.591310	6128.001950	5722.521000	5563.450680	5963.657230	6247.232910	5816.600590
250.00	5035.244140	6365.866210	7760.972660	7263.800780	6796.255860	7338.436520	7689.762210	7090.802250	6098.964840
200.00	6703.461910	8822.394530	9476.303710	8666.940430	9270.834960	9710.733400	8845.133790	7477.558110	6451.646000
150.00	10010.714800	12366.405300	11698.470700	12112.504900	12666.200200	11354.466800	9392.851560	7947.782710	7026.186520
100.00	15179.497100	16507.806600	17055.716800	17234.445300	15120.513700	12161.994100	10219.040000	9368.803710	8548.415040
50.00	23647.652300	25982.525400	24886.789100	21136.835900	17208.939500	14598.472700	12927.520500	11455.719700	9700.786130
0.00	45048.699200	41370.773400	34670.472700	27029.408200	21703.394500	18404.189500	14317.951200	11281.863300	9018.966800
-50.00	92253.765600	65732.031300	45886.265600	32558.369100	23384.695300	17291.650400	13089.499000	10279.052700	8655.065430
-100.00	163625.531000	93172.593800	52466.890600	34563.347700	23899.252000	18059.550800	14420.715800	11781.336900	9807.972660
-150.00	153793.469000	89133.656300	48637.953100	32521.388700	22891.373000	17749.603500	14172.021500	11579.750000	9642.767580
-200.00	83767.117200	57429.179700	39272.558600	27054.919900	19681.212900	14775.744100	11377.292000	9243.965820	7819.227050
-250.00	39931.300800	35131.320300	27929.062500	21590.763700	17494.935500	14500.074200	11408.147500	9128.897460	7416.050290
-300.00	21626.685500	21951.459000	19736.351600	15929.177700	13274.603500	11428.857400	10228.841800	9142.356450	7608.287600
-350.00	14156.029300	14209.636700	14001.682600	13530.041000	11279.887700	8892.476560	7740.704100	7211.632810	6661.977540
-400.00	9582.805660	11047.154300	9761.728520	9764.910160	9843.962890	8423.976560	6845.225590	5791.314450	5206.564450
-450.00	6643.325200	8024.907710	8114.729980	7040.949220	7378.865720	7484.809570	6532.870120	5434.327150	4689.657710
-500.00	4974.135740	5921.811040	6807.246580	6057.964360	5446.814940	5779.566410	5886.086430	5217.348140	4421.770020

0318

4787

*** ISCLT2 - VERSION 93109 *** *** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
 *** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93
 15:11:18
 PAGE 50

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SGOU1PT1 ***
 INCLUDING SOURCE(S): OU1PIT1 ,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD | X-COORD (METERS)
 (METERS) | 400.00 450.00 500.00

500.00	2976.166260	3136.819580	3278.115230
450.00	3605.323730	3772.447270	3587.763180
400.00	4392.950680	4156.236330	3711.827880
350.00	4877.176760	4313.614750	3877.258790
300.00	5081.112300	4519.938480	4154.724610
250.00	5344.631350	4864.236330	4436.907710
200.00	5789.346680	5212.372560	4816.514160
150.00	6518.738770	6066.681150	5644.826170
100.00	7789.719240	7025.535160	5949.097660
50.00	7968.599120	6610.010740	5533.086910
0.00	7303.562990	6274.583010	5497.397950
-50.00	7389.432620	6384.546390	5573.585940
-100.00	8294.603520	7109.081050	6163.192870
-150.00	8157.758790	6994.541990	6066.404300
-200.00	6704.740720	5816.478520	5096.927250
-250.00	6155.192380	5381.679690	4746.903810
-300.00	6339.823730	5336.054690	4532.876950
-350.00	6131.390630	5438.627440	4667.153320
-400.00	4950.364260	4668.130860	4391.483400
-450.00	4213.767580	3798.785400	3619.500240
-500.00	3876.476810	3534.805660	3231.436520

0319

D-III-52

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 51

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SGOU1PT1 ***
INCLUDING SOURCE(S): OU1PT1 ,

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
-1825.00	-2865.00	128.272934	-3460.00	3870.00	50.567192
4722.00	1960.00	203.674042	6470.00	-4590.00	79.180611
5500.00	3460.00	140.507401	5000.00	2390.00	180.162872

0320

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 52

MODELING OPTIONS USED: CONC RURAL FLAT DEFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SG0U1PT2 ***
INCLUDING SOURCE(S): OUIPT2 ,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)								
	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00
500.00	657.237976	699.157227	740.474915	780.015869	944.414978	1003.842350	984.658569	1052.983760	1126.928710
450.00	767.320984	772.108521	825.896851	878.967651	1013.139470	1194.974610	1146.892820	1205.386110	1299.271850
400.00	964.344849	916.487366	924.942200	994.990417	1080.419190	1358.994020	1397.317750	1394.202640	1515.935550
350.00	1084.350590	1177.302000	1119.222780	1130.776000	1222.817870	1492.195560	1723.253050	1633.125980	1793.702640
300.00	1152.468510	1340.809200	1472.508420	1399.863040	1415.870610	1629.735840	2112.983640	2082.535400	2158.119380
250.00	1313.507930	1434.897220	1701.542850	1896.278560	1804.395390	1826.697270	2405.552250	2707.283200	2649.541750
200.00	1497.053470	1652.944950	1836.238650	2231.254150	2535.222660	2418.360110	2730.824710	3597.349120	3509.284180
150.00	1973.594850	2023.990480	2141.386470	2432.712650	3053.056640	3562.026120	3431.768070	4467.274900	4988.372070
100.00	2483.646970	2879.383790	3096.645260	3268.943360	3371.339840	4423.823730	5370.195800	6128.568850	7431.083500
50.00	2562.892580	3104.621090	3820.910640	4786.836430	5485.218260	6158.998540	7471.176760	9484.295900	12512.820300
0.00	2809.720460	3316.350340	3977.903560	5019.941410	6601.946290	8997.443360	12081.322300	16973.205100	26376.337900
-50.00	3605.745610	4349.377930	5355.394040	6763.383790	8824.005860	12196.937500	18490.595700	30781.761700	62202.351600
-100.00	3979.203370	4825.288090	5975.736330	7594.114750	9971.460940	13887.787100	21433.960900	36175.398400	74477.007800
-150.00	3781.276610	4550.685060	5580.723630	7204.251950	9730.775390	13662.798800	18766.138700	25806.630900	37334.003900
-200.00	3806.186520	4717.773930	5951.844240	7661.623540	8912.919920	10077.192400	12165.292000	14604.810500	16396.785200
-250.00	4033.591310	4798.526370	5215.486330	5602.719730	5890.801270	7237.535160	8300.123050	8317.499020	8777.562500
-300.00	3422.332760	3584.904790	3799.028810	4181.775390	4932.291020	5440.295900	4837.386720	5486.920900	5708.347660
-350.00	2677.267330	2889.116940	3110.929200	3564.222170	3836.261720	3401.350340	3480.370360	4315.636720	3882.190430
-400.00	2265.299320	2399.694340	2690.914310	2846.620360	2527.850830	2404.509280	2974.264160	3160.777590	2852.765630
-450.00	1905.123290	2101.491940	2195.212890	1954.961430	1869.050050	2084.995360	2550.403810	2364.698240	2303.455810
-500.00	1685.905640	1744.495240	1558.962770	1496.110110	1595.119870	1855.364870	2036.757450	1802.070920	1900.028810

4787

*** ISCLT2 - VERSION 93109 *** *** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
 *** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93
 15:11:18
 PAGE 53

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SG0U1PT2 ***
 INCLUDING SOURCE(S): OU1PIT2 ,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)									
	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00	
500.00	1499.862430	1557.992430	1597.734990	1670.032470	1904.026490	2334.836670	2250.816410	2230.441650	2221.013430	
450.00	1759.565670	1828.696780	1871.151370	1950.749390	2463.594240	2703.698970	2592.945310	2586.613770	2545.989260	
400.00	2094.015630	2176.884280	2220.368650	2473.860350	3200.682860	3150.592530	3060.443120	3015.543700	2953.542720	
350.00	2534.725590	2634.739500	2675.389650	3376.256100	3930.070310	3693.539550	3634.411620	3557.610110	3859.003420	
300.00	3131.684080	3252.902830	3336.693360	4634.814940	4732.895510	4472.545410	4377.735350	4781.391600	4696.488280	
250.00	3967.361330	4114.062990	4940.237300	6241.685060	5750.715330	5532.438480	6093.295900	5941.864260	4969.019040	
200.00	5186.708980	5361.142580	7380.368160	7901.805180	7235.194340	8051.849120	7770.851560	6339.354490	5375.815430	
150.00	7087.620610	8433.736330	11219.798800	10278.405300	11168.324200	10614.497100	8379.919920	6912.692380	6004.749510	
100.00	10404.690400	14630.794900	16053.714800	16638.334000	15387.417000	11608.479500	9647.744140	8577.407230	7598.592290	
50.00	19036.449200	26932.810500	29116.437500	24486.468800	18822.238300	15129.829100	12734.812500	9899.233400	7611.733890	
0.00	50125.472700	67888.148400	52717.453100	35056.890600	24847.742200	16957.697300	12039.903300	8808.911130	7134.499020	
-50.00	0.000000139991	1.125000	79944.289100	41572.355500	25303.533200	16986.127000	12789.772500	9985.580080	8015.342770	
-100.00	0.000000115199	8.67000	72433.195300	37757.195300	23552.294900	16164.751000	12199.522500	9547.409180	7680.984860	
-150.00	53786.851600	57130.062500	41754.050800	27667.130900	19681.892600	13761.091800	10011.385700	7510.687010	6172.002930	
-200.00	19741.857400	23531.326200	22860.332000	18337.816400	14259.126000	11637.958000	9957.787110	7846.776370	6161.064940	
-250.00	10673.256800	13138.094700	13334.796900	12787.925800	11415.054700	8439.981450	7127.373050	6490.016600	5851.059080	
-300.00	7189.252440	7908.549320	9642.207030	8288.143550	8508.092770	7831.503420	6071.807130	4983.427250	4380.348630	
-350.00	5241.946290	5199.837400	6507.801270	6572.065920	5702.175780	6086.148930	5708.493160	4580.766600	3867.545170	
-400.00	3995.164550	3984.738280	4496.749020	5356.657710	4652.459960	4306.503910	4576.370610	4349.279300	3582.580080	
-450.00	3143.636230	3147.234130	3161.327150	4083.914310	3948.339840	3555.352780	3373.933590	3571.969240	3427.347410	
-500.00	2537.319090	2546.926270	2539.599610	3051.492190	3371.930180	3005.947270	2855.247560	2719.559570	2869.781250	

0322

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 54

* MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SG0U1PT2 ***
INCLUDING SOURCE(S): 0U1PIT2 ,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	400.00	450.00	500.00	X-COORD (METERS)
---------------------	--------	--------	--------	------------------

500.00	2188.198490	2150.524660	2301.079350	
450.00	2499.919920	2686.693120	2675.847410	
400.00	3185.803220	3162.439210	2780.035890	
350.00	3810.363280	3300.984380	2949.411130	
300.00	4004.749760	3525.393310	3191.403560	
250.00	4303.055180	3843.737300	3442.599370	
200.00	4722.209470	4165.175290	3840.809080	
150.00	5510.972170	5034.317380	4593.194340	
100.00	6511.778810	5262.108890	4300.630370	
50.00	5955.077640	4897.008300	4211.675290	
0.00	5925.276860	5001.144040	4279.545410	
-50.00	6579.461910	5500.912600	4670.363280	
-100.00	6318.291500	5292.867680	4501.810550	
-150.00	5171.981450	4400.091310	3791.919430	
-200.00	4922.938480	4123.381840	3580.075440	
-250.00	5069.178220	4172.977050	3474.008060	
-300.00	4115.896480	3827.307370	3541.245850	
-350.00	3408.175540	3014.752440	2838.226560	
-400.00	3090.412840	2768.953860	2486.780760	
-450.00	2881.863040	2528.068600	2295.302250	
-500.00	2773.416500	2371.603030	2113.789550	

0323

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 55

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SGOU1PT2 ***
INCLUDING SOURCE(S): OU1PT2 ,

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
-1825.00	-2865.00	75.847496	-3460.00	3870.00	30.949781
4722.00	1960.00	127.745636	6470.00	-4590.00	48.432926
5500.00	3460.00	87.498642	5000.00	2390.00	112.596115

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 56

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SGQU1PT3 ***
INCLUDING SOURCE(S): OU1P3SQ1, OU1P3SQ2, OU1P3SQ3, OU1P3SQ4, OU1P3SQ5,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00
500.00	5382.081540	5728.812500	6152.261230	6760.863280	7421.778810	7978.630860	8707.782230	9941.365230	11181.273400
450.00	6307.626950	6652.297360	7096.744630	7618.962400	8446.332030	9411.554690	10269.250000	11724.157200	13285.943400
400.00	7344.289060	7857.101560	8405.848630	8833.547850	9782.175780	11136.552700	12493.886700	14203.981400	16053.256800
350.00	8471.925780	9172.020510	10149.864300	10835.012700	11557.304700	13199.196300	15308.953100	17546.562500	19872.896500
300.00	9846.680660	10739.048800	12056.068400	13533.757800	14315.162100	16218.245100	19106.173800	22419.480500	26234.330100
250.00	12266.935500	12956.427700	14116.383800	16514.197300	18582.017600	21017.339800	24771.293000	29632.291000	35946.679700
200.00	15116.511700	17045.591800	18600.187500	20878.570300	23948.685500	28076.343800	33829.632800	42967.359400	54830.277300
150.00	17584.103500	20709.918000	24612.195300	28192.115200	33774.847700	40760.425800	50125.886700	68357.242200	94291.382800
100.00	20944.867200	24744.103500	29905.289100	36583.863300	46824.308600	61851.558600	86426.773400	129948.336000	183979.328000
50.00	25778.029300	31770.302700	39287.882800	50486.605500	68528.671900	96614.257800	159221.391000	217305.313000	229379.281000
0.00	29656.316400	37116.222700	47755.964800	64947.914100	92220.171900	134617.469000	205478.484000	333850.375000	247764.813000
-50.00	32767.386700	41210.507800	53947.738300	74499.085900	111632.555000	165465.359000	137176.406000	199695.594000	313064.750000
-100.00	32986.828100	41975.351600	54444.293000	72446.359400	104430.180000	153716.266000	87554.484400	224168.281000	245062.000000
-150.00	32567.099600	39804.781300	49430.492200	59795.933600	74402.585900	97224.578100	121535.141000	128060.750000	131366.141000
-200.00	30228.828100	33150.015600	37506.878900	43244.804700	49157.582000	55742.160200	59786.824200	68793.203100	72495.734400
-250.00	23107.947300	25254.968800	28561.226600	31615.265600	33059.988300	33283.234400	36903.789100	43427.492200	46442.250000
-300.00	18622.287100	20975.728500	22638.986300	22528.668000	21548.742200	24049.539100	26613.759800	29794.668000	33041.707000
-350.00	16035.447300	17008.509800	16426.875000	15383.771500	17088.308600	18797.683600	20150.212900	21482.125000	24762.337900
-400.00	13243.550800	12724.594700	11617.482400	12539.743200	14073.983400	14832.856400	15697.716800	16765.683600	19051.334000
-450.00	10157.664100	9209.705080	9653.798830	10981.689500	11709.448200	11886.387700	12574.333000	13736.183600	14985.430700
-500.00	7573.899410	7704.926760	8543.704100	9498.813480	9760.694340	9772.308590	10393.962900	11462.473600	12157.785200

(325)

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*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 57

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SG0U1PT3 ***
INCLUDING SOURCE(S): OU1P3SQ1, OU1P3SQ2, OU1P3SQ3, OU1P3SQ4, OU1P3SQ5,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)								
	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00
500.00	12103.128900	12970.162100	15186.069300	16752.841800	17388.625000	16930.023400	16617.666000	16996.140600	17596.679700
450.00	14651.066400	16266.586900	18831.490200	20386.103500	20422.187500	19732.765600	20243.927700	20982.695300	20673.402300
400.00	18279.205100	21079.328100	23838.671900	24989.757800	24157.046900	24594.123000	25535.293000	25051.177700	22907.902300
350.00	23694.261700	27677.558600	30367.628900	30582.287100	30674.658200	31852.562500	31080.839800	28098.029300	24308.437500
300.00	32338.127000	37108.992200	39099.523400	40023.789100	40970.996100	39706.515600	35387.691400	30026.027300	26317.550800
250.00	46356.824200	50613.066400	54897.265600	55250.898400	52670.363300	46069.593800	38473.582000	33385.035200	29906.453100
200.00	67818.835900	77620.117200	80204.921900	73598.562500	63763.902300	52032.046900	44722.789100	39725.019500	34789.039100
150.00	120162.766000	130348.727000	116503.547000	96595.148400	76799.320300	63253.566400	53099.281300	44201.332000	36727.328100
100.00	239313.719000	227474.344000	170483.688000	121575.398000	91260.570300	71198.421900	54860.875000	43016.617200	34908.753900
50.00	317884.000000	386153.594000	224667.063000	143908.688000	98556.054700	71870.007800	55114.660200	44013.418000	36457.402300
0.00	328833.938000	397713.000000	225552.078000	137962.094000	93768.171900	69202.890600	54651.660200	44338.964800	36745.398400
-50.00	393468.250000	294482.594000	178640.219000	120161.336000	86763.882800	65511.183600	51100.070300	41059.828100	34148.246100
-100.00	219925.875000	169949.125000	128389.219000	94453.273400	72888.867200	57575.937500	46328.671900	37847.277300	31275.132800
-150.00	119571.992000	108134.227000	90639.703100	73424.984400	58666.324200	47649.773400	39840.687500	34008.156300	28981.517600
-200.00	76327.437500	72290.757800	65929.203100	57318.414100	50179.570300	41668.925800	34593.058600	29965.834000	26039.902300
-250.00	50936.859400	50595.324200	47857.527300	43886.429700	39777.738300	35535.382800	30940.953100	26634.359400	23199.507800
-300.00	35309.789100	37281.398400	37598.668000	34623.273400	31467.146500	29146.546900	26631.632800	23533.976600	20734.138700
-350.00	26581.408200	27472.316400	28952.312500	28587.785200	26177.394500	24274.447300	22503.777300	20598.644500	18547.345700
-400.00	21117.480500	21272.941400	22219.203100	23089.853500	22196.986300	20559.199200	19370.736300	18125.248000	16698.144500
-450.00	16785.201200	17204.683600	17972.519500	18501.431600	18565.791000	17785.986300	16691.388700	15836.373000	14943.418000
-500.00	13568.601600	14298.964800	14809.223600	15234.029300	15402.975600	15072.596700	14602.244100	13856.654300	13239.268600

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

PAGE 58

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SGOU1PT3 ***
 INCLUDING SOURCE(S): OU1P3SQ1, OU1P3SQ2, OU1P3SQ3, OU1P3SQ4, OU1P3SQ5,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	400.00	450.00	500.00	X-COORD (METERS)
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500.00	17401.027300	16193.745100	14567.637700	
450.00	19083.705100	16988.459000	15487.017600	
400.00	20126.669900	18143.722700	16597.902300	
350.00	21615.431600	19542.519500	17868.359400	
300.00	23747.068400	21573.763700	19865.722700	
250.00	27244.343800	24606.642600	22129.875000	
200.00	30275.050800	26392.585900	22381.851600	
150.00	30055.947300	25224.955100	21559.097700	
100.00	29040.003900	24876.416000	21705.656300	
50.00	30792.904300	26380.494100	22886.087900	
0.00	30985.347700	26510.892600	22974.867200	
-50.00	28998.279300	24955.519500	21732.332000	
-100.00	26235.828100	22559.334000	19787.209000	
-150.00	24772.037100	21234.043000	18396.316400	
-200.00	23079.699200	20429.996100	17965.886700	
-250.00	20655.695300	18462.865200	16723.218800	
-300.00	18715.320300	16809.902300	15162.865200	
-350.00	16619.414100	15122.304700	14020.934600	
-400.00	14999.977500	13622.385700	12570.388700	
-450.00	13916.966800	12656.253900	11470.946300	
-500.00	12587.594700	11819.045900	10847.616200	

0327

*** ISCLT2 - VERSION 93109 ***

*** NOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 59

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SG0U1PT3 ***
INCLUDING SOURCE(S): OU1P3SQ1, OU1P3SQ2, OU1P3SQ3, OU1P3SQ4, OU1P3SQ5,

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
-1825.00	-2865.00	470.358887	-3460.00	3870.00	200.936905
4722.00	1960.00	811.782043	6470.00	-4590.00	300.913513
5500.00	3460.00	550.739746	5000.00	2390.00	705.285889

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*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 60

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SG01PT4 ***
INCLUDING SOURCE(S): OUIPT4 ,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00
500.00	1597.383060	1777.506840	1798.424680	1731.045900	1671.060550	1783.752080	2131.701900	2559.415530	2581.854000
450.00	1673.934080	1884.827640	2118.899170	2156.632570	2080.339600	2006.669920	2287.324710	2818.469240	3107.420650
400.00	1825.967900	1982.740600	2262.521970	2579.398930	2645.064450	2554.048100	2456.547850	3103.056640	3779.298100
350.00	2020.558720	2175.122310	2396.001950	2778.692870	3213.287600	3321.588130	3213.023930	3405.777100	4309.363280
300.00	2470.653560	2491.416260	2649.406250	2958.926030	3493.272710	4111.574710	4295.633300	4265.174800	4902.620610
250.00	3170.410160	3326.676760	3459.277830	3541.781490	3743.920170	4520.546880	5441.395510	5768.307130	6405.337890
200.00	3534.928960	4073.920900	4539.325200	4868.261720	5178.448240	5543.974610	6162.896970	7522.955570	8589.667970
150.00	3620.250980	4209.654300	4942.518550	5864.947750	6972.310060	7728.277830	8706.993160	10281.677700	11901.383800
100.00	3819.147950	4345.396970	5047.399410	6057.750980	7377.237790	9135.302730	11529.166000	14158.574200	18030.664100
50.00	4655.962400	5372.361330	6272.478520	7425.256840	8934.988280	11295.240200	14674.235400	19694.671900	28119.976600
0.00	5659.108400	6592.958500	7780.185060	9320.532230	11367.402300	14166.876000	18131.091800	24578.044900	36893.027300
-50.00	5512.168950	6406.738280	7539.144530	9000.745120	10930.438500	13826.648400	18240.349600	24849.851600	35676.820300
-100.00	5230.035640	6045.413570	7066.613770	8633.851560	10728.585000	13577.093800	17547.189500	22492.652300	28453.214800
-150.00	5297.560060	6269.820310	7501.106450	9082.825200	11146.516600	12795.557600	14361.580100	16929.265600	19756.943400
-200.00	5552.678710	6522.082030	7628.086430	8256.722660	8901.144530	9576.732420	10721.213900	12261.638700	13520.891600
-250.00	5430.150390	5761.872560	6083.515140	6366.838870	6608.192380	7597.027830	8763.678710	9187.857420	9283.675780
-300.00	4428.013670	4570.562500	4747.621090	5126.666990	5806.133790	6553.166020	6757.088870	6311.345210	6212.698240
-350.00	3630.812990	3851.136960	4104.756350	4572.203130	5074.444820	5170.082520	4780.615230	4414.335450	5349.485350
-400.00	3189.973390	3358.541750	3688.842290	4040.080570	4079.913090	3768.537350	3290.894040	3929.655760	4631.447270
-450.00	2802.713130	3042.206050	3292.083250	3300.340330	3048.382810	2687.365970	2962.360840	3499.933350	3762.218990
-500.00	2553.802490	2738.748540	2729.183350	2519.799560	2237.616210	2365.871580	2700.692630	3124.746340	3064.702390

0329

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 61

* MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SGOUIPT4 ***
INCLUDING SOURCE(S): OUIPT4 ,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)								
	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00
500.00	2463.107910	2934.439210	3767.904790	3991.932130	3874.495850	4487.848630	5572.403320	5878.774900	5569.716800
450.00	3001.948490	3434.946780	4470.723630	4741.240720	4577.365720	5885.101560	7073.009770	6819.724610	6371.726560
400.00	3705.925540	4078.107180	5389.442380	5719.866210	6000.282710	7758.730470	8510.227540	7955.515140	7623.595210
350.00	4641.261720	5136.616210	6621.211430	7029.687500	8348.979490	10306.920900	10174.546900	9507.554690	10280.001000
300.00	5907.230470	6696.063480	8322.874020	9159.980470	11713.640600	13387.237300	12524.160200	13145.737300	13595.761700
250.00	7309.550780	8950.300780	10957.118200	13865.534200	16643.023400	17134.900400	17819.789100	17956.570300	15958.487300
200.00	10106.447300	12354.608400	15523.576200	21412.939500	24746.013700	25810.716800	24829.324200	21542.685500	17749.789100
150.00	14450.194300	19985.357400	27233.929700	35336.117200	40674.914100	37878.710900	32710.308600	26599.316400	21686.248000
100.00	24678.119100	35834.371100	56288.796900	74784.007800	72494.437500	56226.781300	42203.281300	32401.146500	25219.808600
50.00	43294.968800	56589.168000	40046.140600	127051.836000	123501.680000	79098.382800	49974.582000	35116.675800	25576.871100
0.00	59920.367200	89247.398400	0.000000	0.000000	148834.719000	85866.578100	52969.250000	34662.523400	26242.410200
-50.00	57049.226600	74891.281300	17643.533200	96022.171900	110917.414000	69749.703100	44506.785200	31583.220700	23296.002000
-100.00	37776.261700	52433.023400	67852.335900	67101.046900	64151.781300	46422.718800	34553.449200	26482.873000	20153.787100
-150.00	22416.591800	27346.662100	30055.085900	34732.207000	35046.726600	31561.474600	26215.082000	21168.990200	17372.357400
-200.00	14458.696300	14881.332000	17211.492200	20659.722700	22427.359400	21551.759800	19705.369100	16200.734400	13674.562500
-250.00	9091.399410	10518.334000	11804.164100	13739.145500	15083.570300	14923.284200	14511.131800	14093.762700	11926.004900
-300.00	7297.390630	7677.504390	8734.122070	9410.366210	10809.835000	11632.990200	10598.119100	10559.527300	10574.914100
-350.00	5604.524900	5742.883790	6902.856930	7116.942380	7884.903320	9248.183590	8609.387700	7845.896000	8166.149410
-400.00	4373.425290	4410.782230	5587.250980	5764.998050	5833.064450	7077.686040	7361.014160	6575.700680	6216.844730
-450.00	3461.104250	3688.849850	4612.207520	4760.524900	4465.773440	5475.453610	6319.926270	5762.657230	5178.308590
-500.00	2773.404790	3131.372800	3870.449460	3995.070310	3773.124270	4274.547850	5053.566410	5070.502440	4608.927730

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 62

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SGOU1PT4 ***
INCLUDING SOURCE(S): OUIP1T4 ,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	400.00	450.00	500.00	X-COORD (METERS)
---------------------	--------	--------	--------	------------------

500.00	5374.580080	5327.688960	5722.786130	
450.00	6316.098630	6810.267090	7077.514650	
400.00	8272.254880	8588.824220	7958.961910	
350.00	10659.115200	9773.420900	8378.008790	
300.00	12298.805700	10353.277300	8752.372070	
250.00	13130.196300	10901.155300	10101.192400	
200.00	15119.486300	13607.547900	12234.690400	
150.00	18831.152300	16081.333000	12978.520500	
100.00	19349.986300	15115.808600	11996.372100	
50.00	19145.093800	15064.630900	12542.554700	
0.00	20741.013700	16798.185500	13880.384800	
-50.00	17699.652300	14338.151400	11951.002000	
-100.00	15675.906300	12427.027300	10017.218800	
-150.00	15180.734400	12647.860400	10342.653300	
-200.00	11779.089800	10712.796900	9714.120120	
-250.00	9638.666990	8232.464840	7746.767580	
-300.00	9144.031250	7574.803710	6379.658690	
-350.00	8228.330080	7235.354980	6111.945310	
-400.00	6509.953610	6587.315430	5870.457030	
-450.00	5088.426270	5316.503910	5396.870610	
-500.00	4319.526370	4247.408690	4438.145020	

0331

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 63

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SGOU1PT4 ***
INCLUDING SOURCE(S): OUIPT4 ,

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
-1825.00	-2865.00	148.863617	-3460.00	3870.00	63.720905
4722.00	1960.00	279.756622	6470.00	-4590.00	100.523552
5500.00	3460.00	186.053604	5000.00	2390.00	240.387207

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*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
 *** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93
 15:11:18
 PAGE 64

MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SGOU18PT ***
 INCLUDING SOURCE(S): OUIBPT ,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)								
	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00
500.00	496.777985	479.557434	482.647308	520.051392	556.761780	596.910950	747.589111	713.928040	777.301392
450.00	525.824097	600.125000	580.616638	585.656799	634.896179	682.386536	827.336121	881.360168	909.280762
400.00	592.341187	640.742798	742.753784	719.513062	726.925415	793.460754	901.563660	1109.374150	1078.542360
350.00	676.447388	729.859924	799.729736	944.311157	917.018311	928.242188	1020.864620	1337.058590	1358.904300
300.00	768.165283	842.201538	922.090637	1027.556760	1242.353390	1211.841670	1229.345090	1517.066280	1826.137700
250.00	916.801636	964.739929	1076.736080	1201.985470	1370.375240	1709.648320	1680.779050	1708.623540	2497.698240
200.00	1200.749760	1339.270140	1396.398680	1422.633060	1630.953250	1919.974490	2502.017580	2498.000000	3068.437010
150.00	1261.995480	1481.195800	1796.005740	2188.638920	2372.073970	2486.140870	2882.544190	4023.791260	4363.667480
100.00	1398.488530	1629.230590	1923.423830	2318.214360	2980.823490	3940.186770	4835.778320	5684.080570	7479.843260
50.00	1518.959470	1787.588260	2137.569090	2606.090090	3253.843750	4188.040530	5884.599120	8953.780270	14543.238300
0.00	1998.115840	2400.885990	2941.780030	3692.131590	4775.258790	6428.425290	9154.333980	14044.519500	25449.507800
-50.00	1894.474000	2263.534180	2753.992680	3425.391110	4377.596190	5791.501460	8487.954100	13386.825200	21502.707000
-100.00	1937.133420	2306.983400	2793.238770	3488.053470	4617.977540	6302.722170	7627.821780	9021.637700	11693.091809
-150.00	1940.068970	2351.446530	2929.840090	3594.704830	3935.213130	4206.814450	4869.706050	6211.145510	5888.973140
-200.00	2034.896730	2273.257810	2408.510010	2541.697510	2824.257080	3188.095460	3819.392090	3407.364260	3772.375980
-250.00	1630.120480	1738.171020	1892.026610	2047.887700	2242.182620	2587.780030	2294.443120	2212.677000	2969.969240
-300.00	1363.648070	1458.330440	1548.755000	1659.696290	1866.133180	1655.001590	1602.658450	1890.880490	2087.949710
-350.00	1156.049680	1210.472050	1277.114750	1408.842650	1252.447630	1216.708130	1311.799680	1613.630860	1504.733520
-400.00	971.362854	1012.982120	1101.448970	982.567688	956.743225	1026.357670	1133.660520	1294.576660	1175.409420
-450.00	823.650146	885.141357	792.704285	773.263916	825.450317	872.035950	1009.261050	1001.233340	981.372375
-500.00	728.469666	654.372864	638.865234	678.885803	715.768066	755.263855	884.872070	794.159180	831.926086

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93
15:11:18
PAGE 65

MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SGQUIBPT ***
INCLUDING SOURCE(S): QUIBPT ,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)									
	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00	
500.00	830.602539	1120.955200	1138.058590	1220.506230	1275.528320	1633.053710	1665.326050	1661.443600	1652.249510	
450.00	980.649780	1353.676510	1372.333500	1469.895260	1647.537840	2061.111080	1981.688350	1980.800420	1942.082150	
400.00	1177.062990	1668.438600	1687.538210	1802.591670	2311.324950	2484.447270	2420.636230	2377.026610	2386.948000	
350.00	1441.336670	2108.599120	2125.107670	2295.122070	3244.082030	3026.475830	2983.200440	3001.864500	3240.292720	
300.00	1808.950070	2750.322750	2756.116210	3552.788330	4116.774410	3864.726070	3902.628420	4230.465820	3507.868900	
250.00	2370.210450	3745.822020	3715.519290	5568.258790	5306.122070	5303.009280	5771.389650	4640.699710	3865.756100	
200.00	3597.816410	5415.936520	6306.476560	8174.251460	7681.496090	8364.201170	6444.515140	5175.778810	4341.569340	
150.00	5798.298830	8479.329100	12071.863300	12805.695300	13334.685500	9597.155270	7424.120120	6486.628910	5632.099120	
100.00	10478.761700	17671.099600	26131.546900	24621.437500	17121.484400	13031.107400	10193.420900	7191.031250	5228.444820	
50.00	26574.306600	56628.418000	73674.921900	39991.480500	22834.261700	13690.447300	8883.260740	6715.523440	5262.848140	
0.00	60658.043000	0.000000	128679.164000	47711.234400	23910.177700	15377.474600	10711.287100	7905.175290	6086.010250	
-50.00	36181.058600	50160.101600	55144.511700	30750.255900	18372.718800	11462.363300	7620.706540	5836.575200	4628.610350	
-100.00	13320.614300	16695.691400	20326.500000	17722.683600	12421.473600	9686.569340	7979.395020	5802.688480	4346.215330	
-150.00	6660.214360	8269.176760	10023.030300	9745.643550	9612.679690	6932.665530	5232.347170	4759.098630	4245.392580	
-200.00	3983.717530	5296.637700	5524.216800	6700.187990	5741.072750	6031.243650	4643.684080	3689.212400	3113.577150	
-250.00	2521.373780	3668.661130	3456.421390	4711.236820	4222.021000	3940.160640	4153.957520	3335.721680	2751.719970	
-300.00	1916.055910	2694.786380	2573.689450	3118.091310	3411.641360	3009.264650	2883.502930	3039.853030	2516.543210	
-350.00	1513.882200	2064.786130	1989.555910	2108.334960	2787.255860	2433.412350	2296.008540	2207.764650	2324.956540	
-400.00	1227.439580	1632.569090	1583.251100	1681.312380	2029.169920	2071.109620	1914.268920	1812.653810	1748.810790	
-450.00	1016.280460	1323.545900	1289.797240	1373.705320	1495.929080	1773.804440	1609.198850	1547.745120	1469.886350	
-500.00	856.120300	1095.125490	1071.188230	1142.574100	1189.795170	1433.979980	1394.122680	1329.324100	1278.466190	

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***07/16/93
15:11:18
PAGE 66

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SG0U18PT ***
INCLUDING SOURCE(S): OU18PT ,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	400.00	450.00	500.00	X-COORD (METERS)
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500.00	1619.188230	1623.494870	1734.849490	
450.00	1947.802000	2085.694090	1829.501950	
400.00	2565.934570	2217.296140	1965.479740	
350.00	2749.751220	2399.708980	2151.562260	
300.00	3000.588870	2646.753660	2341.879390	
250.00	3337.958980	2896.848140	2585.250980	
200.00	3881.182130	3511.155030	3059.530760	
150.00	4467.299320	3483.324460	2816.646000	
100.00	4147.354000	3439.035400	2898.362060	
50.00	4238.893550	3490.464600	2926.807620	
0.00	4833.774410	3935.320070	3268.853760	
-50.00	3765.540280	3127.336910	2641.795410	
-100.00	3476.391110	2919.594730	2487.738770	
-150.00	3512.945070	2807.768310	2299.232180	
-200.00	2815.849120	2613.888430	2361.360840	
-250.00	2389.023190	2083.125000	1858.989260	
-300.00	2133.608400	1891.371700	1680.737670	
-350.00	1969.558960	1704.867070	1535.504520	
-400.00	1838.716670	1586.010380	1395.310670	
-450.00	1422.397710	1492.813960	1307.507200	
-500.00	1217.832640	1182.630370	1241.680420	

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*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
 *** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93
 15:11:18
 PAGE 67

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SGOU1BPT ***
 INCLUDING SOURCE(S): OU1BPIT ,

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
-1825.00	-2865.00	41.534149	-3460.00	3870.00	17.835642
4722.00	1960.00	75.774414	6470.00	-4590.00	27.469433
5500.00	3460.00	50.828487	5000.00	2390.00	65.545303

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*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 68

** MODELING OPTIONS USED: COWC RURAL FLAT DEFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SG0U1ALL ***

INCLUDING SOURCE(S): OUIPIT1 , OUIPIT2 , OUIP3SQ1, OUIP3SQ2, OUIP3SQ3, OUIP3SQ4, OUIP3SQ5,

OUIPIT4 , OUIPIT ,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	X-COORD (METERS)									
	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	
500.00	9155.535160	9770.865230	10470.591800	11213.247100	11967.542000	12767.958000	14051.635700	16107.941400	17860.228500	
450.00	10401.162100	11098.556600	12003.059600	12882.621100	13788.668000	14877.150400	16206.318400	18740.814500	21136.677700	
400.00	11971.179700	12722.333000	13802.406300	14913.159200	16148.002000	17678.125000	19163.255900	22259.453100	25390.671900	
350.00	13739.939500	14738.449200	16053.860400	17628.335900	19198.843800	21163.736300	23474.654300	26798.273400	30846.037100	
300.00	16131.115200	17222.076200	18905.207000	21019.332000	23080.918000	25894.962900	29322.656300	33711.101600	39346.027300	
250.00	19959.763700	21038.334000	22604.363300	25408.480500	28415.941400	32455.437500	37553.121100	43971.867200	52677.316400	
200.00	23828.050800	27016.113300	29384.683600	32280.685500	36537.707000	42118.027300	49410.359400	61731.621100	76486.687500	
150.00	27087.015600	31598.345700	37290.078100	42667.839800	50149.710900	59368.785200	70642.765600	93899.679700	123901.797000	
100.00	32009.996100	37010.101600	44176.992200	53400.750000	66083.632800	85595.835900	115554.563000	165373.797000	228073.375000	
50.00	39196.406300	47091.636700	56902.695300	71418.046900	93636.453100	127050.664000	197710.734000	269273.969000	303785.031000	
0.00	45426.726600	55921.972700	70247.664100	91798.429700	125761.273000	177244.375000	260885.094000	412968.531000	572172.094000	
-50.00	49226.191400	61006.996100	78211.039100	104920.742000	150895.453000	217788.906000	313075.125000	451959.719000	62095.625000	
-100.00	51559.097700	64293.937500	81812.593800	107541.453000	151432.328000	219814.813000	319345.188000	460910.375000	659685.313000	
-150.00	51852.480500	63205.031300	78417.984400	96931.742200	123933.805000	165735.531000	228135.188000	3268163.813000	194346.047000	
-200.00	49261.933600	56295.128900	66034.656300	78487.414100	93095.648400	111192.727000	133630.250000	170768.141000	177162.453000	
-250.00	42216.589800	47602.433600	54533.867200	60220.226600	65416.519500	72116.335900	81317.125000	94441.546900	103759.375000	
-300.00	35714.632800	39203.957000	42080.793000	44067.781300	46315.230500	51450.046900	54472.535200	59605.753900	66808.531300	
-350.00	29498.851600	31198.334000	32038.644500	33279.250000	36034.722700	37450.457000	38959.910200	42541.726600	47310.355500	
-400.00	24345.798800	24803.404300	25160.482400	26659.419900	27414.357400	28103.046900	29780.097700	32602.164100	36328.285200	
-450.00	19788.562500	19827.781300	20600.502000	21237.179700	21628.609400	22644.755900	24050.705100	26090.140600	28681.103500	
-500.00	16131.826200	16456.746100	16746.949200	17194.804700	17971.253900	18868.505900	19764.457000	21583.152300	23231.957000	

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4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 69

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SG0U1ALL ***

INCLUDING SOURCE(S): OU1P1T1 , OU1P1T2 , OU1P3SQ1, OU1P3SQ2, OU1P3SQ3, OU1P3SQ4, OU1P3SQ5,
OU1P1T4 , OU1BP1T ,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3

Y-COORD (METERS)	X-COORD (METERS)									
	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00	
500.00	19065.429700	20789.902300	23975.154300	26369.418000	27702.398400	28562.164100	29185.755900	29836.890600	30073.027300	
450.00	22894.996100	25423.130900	29238.166000	31963.724600	32847.875000	33963.851600	35407.148400	35846.207000	34941.777300	
400.00	28173.900400	31955.019500	36627.425800	39273.765600	39955.085900	42062.984400	43555.613300	42347.468800	40065.335900	
350.00	35757.429700	41030.023400	46330.418000	48490.519500	51138.492200	53629.253900	52517.808600	49114.906300	46876.523400	
300.00	47315.664100	54437.089800	59451.800800	63499.371100	67256.828100	66994.468800	62155.871100	58430.851600	53934.269500	
250.00	65039.187500	73789.117200	82271.109400	88190.171900	87166.484400	81378.375000	75847.820300	69014.968800	60798.683600	
200.00	93413.265600	109574.203000	118891.641000	119754.500000	112697.438000	103969.547000	92612.609400	80260.398400	68707.859400	
150.00	157509.594000	179613.547000	178727.609000	167127.875000	154643.438000	132698.391000	111006.477000	92147.750000	77076.617200	
100.00	300054.781000	312118.406000	286013.469000	254853.625000	211384.422000	164226.797000	127124.359000	100555.000000	81504.015600	
50.00	430437.375000	552286.500000	392391.375000	356575.281000	280923.156000	194387.141000	139634.828000	107200.570000	84609.648400	
0.00	544586.563000	596219.313000	441619.156000	247759.625000	313064.219000	205808.828000	144690.047000	106997.438000	85227.289100	
-50.00	578952.313000	625257.125000	377258.813000	321064.500000	264742.250000	181001.016000	129106.828000	98744.257800	78743.265600	
-100.00	434648.250000	447450.344000	341468.156000	251597.563000	196913.656000	147909.516000	115481.758000	91461.585900	73264.101600	
-150.00	356229.156000	290013.813000	221109.813000	178091.344000	145899.000000	117654.609000	95471.515600	79026.687500	66414.039100	
-200.00	198278.828000	173429.234000	150797.813000	130071.063000	112288.344000	95665.625000	80277.195300	66946.523400	56808.335900	
-250.00	113154.188000	113051.734000	104381.977000	96715.500000	87993.320300	77338.890600	68141.562500	59682.757800	51144.339800	
-300.00	73339.171900	77513.695300	78305.039100	71369.054700	67471.320300	63049.164100	56413.902300	51259.140600	45814.230500	
-350.00	53097.796900	54689.457000	58354.207000	57915.171900	53831.617200	50934.668000	46858.367200	42444.703100	39567.972700	
-400.00	40296.320300	42348.183600	43648.179700	45657.734400	44555.640600	42438.476600	40067.617200	36654.195300	33452.945300	
-450.00	31049.544900	33389.218800	35150.582000	35760.527300	35854.703100	36075.406300	34527.316400	32153.074200	29708.619100	
-500.00	24709.582000	26994.201200	29097.707000	29481.132800	29184.642600	29566.640600	29791.265600	28193.386700	26418.214800	

0338

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
 *** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93
 15:11:18
 PAGE 70

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SGOU1ALL ***

INCLUDING SOURCE(S): OU1PIT1 , OU1PIT2 , OU1P3SQ1, OU1P3SQ2, OU1P3SQ3, OU1P3SQ4, OU1P3SQ5,
 OU1PIT4 , OU1BPIT ,

*** NETWORK ID: ONSTEGRD ; NETWORK TYPE: GRIDCART ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

Y-COORD (METERS)	400.00	450.00	500.00	X-COORD (METERS)
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500.00	29559.160200	28432.273400	27604.470700	
450.00	33452.847700	32343.560500	30657.646500	
400.00	38543.613300	36268.519500	33014.210900	
350.00	43711.835900	39330.250000	35224.601600	
300.00	48132.324200	42619.125000	38306.101600	
250.00	53360.179700	47112.621100	42695.824200	
200.00	59787.277300	52888.835900	46333.398400	
150.00	65384.109400	55890.609400	47592.281300	
100.00	66838.835900	55718.902300	46850.121100	
50.00	68100.562500	56442.613300	48100.214800	
0.00	69788.976600	58520.125000	49901.050800	
-50.00	64432.367200	54306.468800	46569.078100	
-100.00	60001.015600	50307.902300	42957.168000	
-150.00	56795.460900	48084.304700	40896.523400	
-200.00	49302.316400	43696.539100	38718.367200	
-250.00	43907.757800	38333.109400	34549.886700	
-300.00	40448.683600	35439.437500	31297.384800	
-350.00	36356.871100	32515.906300	29173.763700	
-400.00	31389.425800	29232.794900	26714.421900	
-450.00	27523.421900	25792.425800	24090.128900	
-500.00	24774.843800	23155.492200	21872.666000	

0339

4787

*** ISCLT2 - VERSION 93109 ***

*** NOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 71

* MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: SG01ALL ***

INCLUDING SOURCE(S): OU1PIT1 , OU1PIT2 , OU1P3S01, OU1P3S02, OU1P3S03, OU1P3S04, OU1P3S05,
OU1PIT4 , OU1BPIT ,

*** DISCRETE CARTESIAN RECEPTOR POINTS ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

X-COORD (M)	Y-COORD (M)	CONC	X-COORD (M)	Y-COORD (M)	CONC
-1825.00	-2865.00	864.877075	-3460.00	3870.00	364.010437
4722.00	1960.00	1498.732670	6470.00	-4590.00	556.520020
5500.00	3460.00	1015.627870	5000.00	2390.00	1303.977420

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***07/16/93
15:11:18
PAGE 72

* MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OU1PIT1 ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	163625.531000	AT (	-50.00, -100.00) GC	6.	89133.656300	AT (	0.00, -150.00) GC
2.	153793.469000	AT (	-50.00, -150.00) GC	7.	83767.117200	AT (	-50.00, -200.00) GC
3.	93172.593800	AT (	0.00, -100.00) GC	8.	71701.125000	AT (	-150.00, -200.00) GC
4.	92253.765600	AT (	-50.00, -50.00) GC	9.	70976.671900	AT (	-100.00, -200.00) GC
5.	91156.015600	AT (	-150.00, -150.00) GC	10.	69648.992200	AT (	-100.00, -50.00) GC

*** THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OU1PIT2 ***

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	139991.125000	AT (	0.00, -50.00) GC	6.	67888.148400	AT (	0.00, 0.00) GC
2.	115199.867000	AT (	0.00, -100.00) GC	7.	62202.351600	AT (	-100.00, -50.00) GC
3.	79944.289100	AT (	50.00, -50.00) GC	8.	57130.062500	AT (	0.00, -150.00) GC
4.	74477.007800	AT (	-100.00, -100.00) GC	9.	53786.851600	AT (	-50.00, -150.00) GC
5.	72433.195300	AT (	50.00, -100.00) GC	10.	52717.453100	AT (	50.00, 0.00) GC

*** THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OU1P3SQ1 ***

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	151107.859000	AT (	-50.00, 50.00) GC	6.	74992.007800	AT (	-100.00, 100.00) GC
2.	121445.070000	AT (	-50.00, 0.00) GC	7.	66662.304700	AT (	0.00, 0.00) GC
3.	94881.734400	AT (	-50.00, 100.00) GC	8.	64457.906300	AT (	-150.00, 50.00) GC
4.	87959.976600	AT (	-150.00, 0.00) GC	9.	62750.433600	AT (	-100.00, -50.00) GC
5.	79352.585900	AT (	0.00, 50.00) GC	10.	61809.304700	AT (	0.00, 100.00) GC

*** THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OU1P3SQ2 ***

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	168507.188000	AT (	0.00, 50.00) GC	6.	79146.273400	AT (	-100.00, 50.00) GC
2.	106175.094000	AT (	0.00, 0.00) GC	7.	69572.867200	AT (	50.00, 0.00) GC
3.	84140.023400	AT (	0.00, 100.00) GC	8.	61174.339800	AT (	-50.00, 100.00) GC
4.	82367.242200	AT (	50.00, 50.00) GC	9.	57695.210900	AT (	50.00, 100.00) GC
5.	81319.156300	AT (	-100.00, 0.00) GC	10.	56096.683600	AT (	0.00, -50.00) GC

*** RECEPTOR TYPES: GC = GRIDCART
GP = GRIDPOLR
DC = DISCCART
DP = DISCPOLR
BD = BOUNDARY

0341

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 73

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QU1P3SQ3 ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	146008.234000	AT (	-100.00, -50.00) GC	6.	86787.007800	AT (	-250.00, -100.00) GC
2.	112444.945000	AT (	-100.00, -100.00) GC	7.	79556.226600	AT (	-250.00, -50.00) GC
3.	111975.664000	AT (	-150.00, 0.00) GC	8.	76433.367200	AT (	-50.00, -50.00) GC
4.	103454.555000	AT (	-150.00, -100.00) GC	9.	72212.234400	AT (	-200.00, -150.00) GC
5.	103089.930000	AT (	-100.00, 0.00) GC	10.	70809.820300	AT (	-150.00, -150.00) GC

*** THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QU1P3SQ4 ***

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	140161.109000	AT (	-50.00, 0.00) GC	6.	75062.328100	AT (	-50.00, -100.00) GC
2.	136049.328000	AT (	-50.00, -50.00) GC	7.	74161.726600	AT (	0.00, -50.00) GC
3.	90798.578100	AT (	-150.00, -50.00) GC	8.	73854.875000	AT (	-100.00, 50.00) GC
4.	76013.515600	AT (	0.00, 0.00) GC	9.	67094.882800	AT (	-150.00, -100.00) GC
5.	75972.312500	AT (	-50.00, 50.00) GC	10.	66661.632800	AT (	-100.00, -100.00) GC

*** THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QU1P3SQ5 ***

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	104583.375000	AT (	0.00, 0.00) GC	6.	47572.535200	AT (	0.00, 50.00) GC
2.	75589.125000	AT (	0.00, -50.00) GC	7.	43191.308600	AT (	-50.00, 50.00) GC
3.	73213.484400	AT (	-50.00, -50.00) GC	8.	41234.734400	AT (	50.00, 0.00) GC
4.	63355.710900	AT (	-100.00, 0.00) GC	9.	34275.937500	AT (	50.00, -50.00) GC
5.	63251.863300	AT (	-100.00, -50.00) GC	10.	31701.097700	AT (	50.00, 50.00) GC

*** THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: QU1P1T4 ***

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	148834.719000	AT (	150.00, 0.00) GC	6.	89247.398400	AT (	0.00, 0.00) GC
2.	127051.836000	AT (	100.00, 50.00) GC	7.	85866.578100	AT (	200.00, 0.00) GC
3.	123501.680000	AT (	150.00, 50.00) GC	8.	79098.382800	AT (	200.00, 50.00) GC
4.	110917.414000	AT (	150.00, -50.00) GC	9.	74891.281300	AT (	0.00, -50.00) GC
5.	96022.171900	AT (	100.00, -50.00) GC	10.	74784.007800	AT (	100.00, 100.00) GC

*** RECEPTOR TYPES: GC = GRIDCART
 GP = GRIDPOLR
 DC = DISCCART
 DP = DISCPOLR
 BD = BOUNDARY

*** ISCLT2 - VERSION 93109 *** *** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
 *** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***
 *** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

07/16/93
 15:11:18
 PAGE 74

*** THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: OUIBPIT ***

** CONC OF POLL1 IN MICROGRAMS/M**3

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	128679.164000	AT (	50.00, 0.00) GC	6.	50160.101600	AT (	0.00, -50.00) GC
2.	73674.921900	AT (	50.00, 50.00) GC	7.	47711.234400	AT (	100.00, 0.00) GC
3.	60658.043000	AT (	-50.00, 0.00) GC	8.	39991.480500	AT (	100.00, 50.00) GC
4.	56628.418000	AT (	0.00, 50.00) GC	9.	36181.058600	AT (	-50.00, -50.00) GC
5.	55144.511700	AT (	50.00, -50.00) GC	10.	30750.255900	AT (	100.00, -50.00) GC

*** RECEPTOR TYPES: GC = GRIDCART
 GP = GRIDPOLR
 DC = DISCCART
 DP = DISCPOLR
 BD = BOUNDARY

0343

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*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

** MODELING OPTIONS USED: CONC RURAL FLAT DEFAULT

PAGE 75

*** THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU1PT1 ***
 INCLUDING SOURCE(S): OU1PIT1 ,

** CONC OF POLL1 IN MICROGRAMS/M**3

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	163625.531000	AT (	-50.00, -100.00) GC	6.	89133.656300	AT (	0.00, -150.00) GC
2.	153793.469000	AT (	-50.00, -150.00) GC	7.	83767.117200	AT (	-50.00, -200.00) GC
3.	93172.593800	AT (	0.00, -100.00) GC	8.	71701.125000	AT (	-150.00, -200.00) GC
4.	92253.765600	AT (	-50.00, -50.00) GC	9.	70976.671900	AT (	-100.00, -200.00) GC
5.	91156.015600	AT (	-150.00, -150.00) GC	10.	69648.992200	AT (	-100.00, -50.00) GC

*** THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU1PT2 ***
 INCLUDING SOURCE(S): OU1PIT2 ,

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	139991.125000	AT (	0.00, -50.00) GC	6.	67888.148400	AT (	0.00, 0.00) GC
2.	115199.867000	AT (	0.00, -100.00) GC	7.	62202.351600	AT (	-100.00, -50.00) GC
3.	79944.289100	AT (	50.00, -50.00) GC	8.	57130.062500	AT (	0.00, -150.00) GC
4.	74477.007800	AT (	-100.00, -100.00) GC	9.	53786.851600	AT (	-50.00, -150.00) GC
5.	72433.195300	AT (	50.00, -100.00) GC	10.	52717.453100	AT (	50.00, 0.00) GC

*** THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU1PT3 ***
 INCLUDING SOURCE(S): OU1P3SQ1, OU1P3SQ2, OU1P3SQ3, OU1P3SQ4, OU1P3SQ5,

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	397713.000000	AT (	0.00, 0.00) GC	6.	317884.000000	AT (	-50.00, 50.00) GC
2.	393468.250000	AT (	-50.00, -50.00) GC	7.	313064.750000	AT (	-100.00, -50.00) GC
3.	386153.594000	AT (	0.00, 50.00) GC	8.	294482.594000	AT (	0.00, -50.00) GC
4.	333850.375000	AT (	-150.00, 0.00) GC	9.	247764.813000	AT (	-100.00, 0.00) GC
5.	328833.938000	AT (	-50.00, 0.00) GC	10.	245062.000000	AT (	-100.00, -100.00) GC

*** RECEPTOR TYPES: GC = GRIDCART
 GP = GRIDPOLR
 DC = DISCCART
 DP = DISCPOLR
 BD = BOUNDARY

4787

*** ISCLT2 - VERSION 93109 *** *** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
 *** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93
 15:11:18
 PAGE 76

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU1PT4 ***
 INCLUDING SOURCE(S): OU1PIT4 ,

** CONC OF POLL1 IN MICROGRAMS/M**3 **

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	148834.719000	AT (	150.00, 0.00) GC	6.	89247.398400	AT (	0.00, 0.00) GC
2.	127051.836000	AT (	100.00, 50.00) GC	7.	85866.578100	AT (	200.00, 0.00) GC
3.	123501.680000	AT (	150.00, 50.00) GC	8.	79098.382800	AT (	200.00, 50.00) GC
4.	110917.414000	AT (	150.00, -50.00) GC	9.	74891.281300	AT (	0.00, -50.00) GC
5.	96022.171900	AT (	100.00, -50.00) GC	10.	74784.007800	AT (	100.00, 100.00) GC

*** THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU18PT ***
 INCLUDING SOURCE(S): OU18PIT ,

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	128679.164000	AT (	50.00, 0.00) GC	6.	50160.101600	AT (	0.00, -50.00) GC
2.	73674.921900	AT (	50.00, 50.00) GC	7.	47711.234400	AT (	100.00, 0.00) GC
3.	60658.043000	AT (	-50.00, 0.00) GC	8.	39991.480500	AT (	100.00, 50.00) GC
4.	56628.418000	AT (	0.00, 50.00) GC	9.	36181.058600	AT (	-50.00, -50.00) GC
5.	55144.511700	AT (	50.00, -50.00) GC	10.	30750.255900	AT (	100.00, -50.00) GC

*** THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU1ALL ***
 INCLUDING SOURCE(S): OU1PIT1 , OU1PIT2 , OU1P3SQ1, OU1P3SQ2, OU1P3SQ3, OU1P3SQ4, OU1P3SQ5,
 OU1PIT4 , OU18PIT ,

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	625257.125000	AT (	0.00, -50.00) GC	6.	502095.625000	AT (	-100.00, -50.00) GC
2.	596219.313000	AT (	0.00, 0.00) GC	7.	447450.344000	AT (	0.00, -100.00) GC
3.	578952.313000	AT (	-50.00, -50.00) GC	8.	441619.156000	AT (	50.00, 0.00) GC
4.	552286.500000	AT (	0.00, 50.00) GC	9.	434648.250000	AT (	-50.00, -100.00) GC
5.	544586.563000	AT (	-50.00, 0.00) GC	10.	430437.375000	AT (	-50.00, 50.00) GC

*** RECEPTOR TYPES: GC = GRIDCART
 GP = GRIDPOLR
 DC = DISCCART
 DP = DISCPOLR
 BD = BOUNDARY

0345

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***07/16/93
15:11:18
PAGE 77

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** SOURCE OUIPT1 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU1PT1 ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	163625.531000	AT (	-50.00, -100.00) GC	6.	89133.656300	AT (	0.00, -150.00) GC
2.	153793.469000	AT (	-50.00, -150.00) GC	7.	83767.117200	AT (	-50.00, -200.00) GC
3.	93172.593800	AT (	0.00, -100.00) GC	8.	71701.125000	AT (	-150.00, -200.00) GC
4.	92253.765600	AT (	-50.00, -50.00) GC	9.	70976.671900	AT (	-100.00, -200.00) GC
5.	91156.015600	AT (	-150.00, -150.00) GC	10.	69648.992200	AT (	-100.00, -50.00) GC

*** RECEPTOR TYPES: GC = GRIDCART
GP = GRIDPOLR
DC = DISCCART
DP = DISCPOLR
BD = BOUNDARY

0346

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 78

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** SOURCE QU1PIT2 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU1PT2 ***

** CONC OF POLL1 IN MICROGRAMS/M**3

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	139991.125000	AT (	0.00, -50.00) GC	6.	67888.148400	AT (	0.00, 0.00) GC
2.	115199.867000	AT (	0.00, -100.00) GC	7.	62202.351600	AT (	-100.00, -50.00) GC
3.	79944.289100	AT (	50.00, -50.00) GC	8.	57130.062500	AT (	0.00, -150.00) GC
4.	74477.007800	AT (	-100.00, -100.00) GC	9.	53786.851600	AT (	-50.00, -150.00) GC
5.	72433.195300	AT (	50.00, -100.00) GC	10.	52717.453100	AT (	50.00, 0.00) GC

*** RECEPTOR TYPES: GC = GRIDCART
GP = GRIDPOLR
DC = DISCCART
DP = DISCPOLR
BD = BOUNDARY

0347

4787

*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 79

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** SOURCE QU1P3SQ1 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU1PT3 ***

** CONC OF POLL1 IN MICROGRAMS/M**3

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	66662.304700	AT (	0.00, 0.00) GC	6.	151107.859000	AT (	-50.00, 50.00) GC
2.	59670.082000	AT (	-50.00, -50.00) GC	7.	62750.433600	AT (	-100.00, -50.00) GC
3.	79352.585900	AT (	0.00, 50.00) GC	8.	42348.937500	AT (	0.00, -50.00) GC
4.	87959.976600	AT (	-150.00, 0.00) GC	9.	0.000000	AT (	-100.00, 0.00) GC
5.	121445.070000	AT (	-50.00, 0.00) GC	10.	26584.599600	AT (	-100.00, -100.00) GC

*** SOURCE QU1P3SQ2 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU1PT3 ***

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	106175.094000	AT (	0.00, 0.00) GC	6.	0.000000	AT (	-50.00, 50.00) GC
2.	48101.960900	AT (	-50.00, -50.00) GC	7.	41054.203100	AT (	-100.00, -50.00) GC
3.	168507.188000	AT (	0.00, 50.00) GC	8.	56096.683600	AT (	0.00, -50.00) GC
4.	44083.582000	AT (	-150.00, 0.00) GC	9.	81319.156300	AT (	-100.00, 0.00) GC
5.	0.000000	AT (	-50.00, 0.00) GC	10.	18287.470700	AT (	-100.00, -100.00) GC

*** SOURCE QU1P3SQ3 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU1PT3 ***

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	44278.722700	AT (	0.00, 0.00) GC	6.	47612.500000	AT (	-50.00, 50.00) GC
2.	76433.367200	AT (	-50.00, -50.00) GC	7.	146008.234000	AT (	-100.00, -50.00) GC
3.	36201.355500	AT (	0.00, 50.00) GC	8.	46286.113300	AT (	0.00, -50.00) GC
4.	111975.664000	AT (	-150.00, 0.00) GC	9.	103089.930000	AT (	-100.00, 0.00) GC
5.	67227.750000	AT (	-50.00, 0.00) GC	10.	112444.945000	AT (	-100.00, -100.00) GC

*** SOURCE QU1P3SQ4 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU1PT3 ***

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	76013.515600	AT (	0.00, 0.00) GC	6.	75972.312500	AT (	-50.00, 50.00) GC
2.	136049.328000	AT (	-50.00, -50.00) GC	7.	0.000000	AT (	-100.00, -50.00) GC
3.	54519.937500	AT (	0.00, 50.00) GC	8.	74161.726600	AT (	0.00, -50.00) GC
4.	63819.402300	AT (	-150.00, 0.00) GC	9.	0.000000	AT (	-100.00, 0.00) GC
5.	140161.109000	AT (	-50.00, 0.00) GC	10.	66661.632800	AT (	-100.00, -100.00) GC

*** RECEPTOR TYPES: GC = GRIDCART
GP = GRIDPOLR
DC = DISCCART
DP = DISCPOLR
BD = BOUNDARY

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*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 80

MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** SOURCE OUIP3S05 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU1PT3 ***

** CONC OF POLL1 IN MICROGRAMS/M**3

**

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	104583.375000	AT (	0.00, 0.00) GC	6.	43191.308600	AT (	-50.00, 50.00) GC
2.	73213.484400	AT (	-50.00, -50.00) GC	7.	63251.863300	AT (	-100.00, -50.00) GC
3.	47572.535200	AT (	0.00, 50.00) GC	8.	75589.125000	AT (	0.00, -50.00) GC
4.	26011.740200	AT (-150.00, 0.00) GC	9.	63355.710900	AT (-100.00, 0.00) GC
5.	0.000000	AT (-50.00, 0.00) GC	10.	21083.335900	AT (-100.00, -100.00) GC

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*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

* MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

PAGE 81

*** SOURCE QJ1PT4 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SQJ1PT4 ***

** CONC OF POLL1 IN MICROGRAMS/M**3

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	148834.719000	AT (	150.00, 0.00) GC	6.	89247.398400	AT (	0.00, 0.00) GC
2.	127051.836000	AT (	100.00, 50.00) GC	7.	85866.578100	AT (	200.00, 0.00) GC
3.	123501.680000	AT (	150.00, 50.00) GC	8.	79098.382800	AT (	200.00, 50.00) GC
4.	110917.414000	AT (	150.00, -50.00) GC	9.	74891.281300	AT (	0.00, -50.00) GC
5.	96022.171900	AT (	100.00, -50.00) GC	10.	74784.007800	AT (	100.00, 100.00) GC

*** RECEPTOR TYPES: GC = GRIDCART
 GP = GRIDPOLR
 DC = DISCCART
 DP = DISCPOLR
 BD = BOUNDARY

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*** ISCL72 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93

15:11:18

PAGE 82

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** SOURCE QU18P17 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGQU18PT ***

** CONC OF POLL1 IN MICROGRAMS/M**3

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	128679.164000	AT (	50.00, 0.00) GC	6.	50160.101600	AT (	0.00, -50.00) GC
2.	73674.921900	AT (	50.00, 50.00) GC	7.	47711.234400	AT (	100.00, 0.00) GC
3.	60658.043000	AT (	-50.00, 0.00) GC	8.	39991.480500	AT (	100.00, 50.00) GC
4.	56628.418000	AT (	0.00, 50.00) GC	9.	36181.058600	AT (	-50.00, -50.00) GC
5.	55144.511700	AT (	50.00, -50.00) GC	10.	30750.255900	AT (	100.00, -50.00) GC

*** RECEPTOR TYPES: GC = GRIDCART
 GP = GRIDPOLR
 DC = DISCCART
 DP = DISCPOLR
 BD = BOUNDARY

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*** ISCLT2 - VERSION 93109 *** *** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
 *** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

07/16/93
 15:11:18
 PAGE 83

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** SOURCE QU1PIT1 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU1ALL ***

** CONC OF POLL1 IN MICROGRAMS/M**3 **

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	65732.031300	AT (	0.00, -50.00) GC	6.	69648.992200	AT (	-100.00, -50.00) GC
2.	41370.773400	AT (	0.00, 0.00) GC	7.	93172.593800	AT (	0.00, -100.00) GC
3.	92253.765600	AT (	-50.00, -50.00) GC	8.	34670.472700	AT (	50.00, 0.00) GC
4.	25982.525400	AT (	0.00, 50.00) GC	9.	163625.531000	AT (	-50.00, -100.00) GC
5.	45048.699200	AT (	-50.00, 0.00) GC	10.	23647.652300	AT (	-50.00, 50.00) GC

*** SOURCE QU1PIT2 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU1ALL ***

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	139991.125000	AT (	0.00, -50.00) GC	6.	62202.351600	AT (	-100.00, -50.00) GC
2.	67888.148400	AT (	0.00, 0.00) GC	7.	115199.867000	AT (	0.00, -100.00) GC
3.	0.000000	AT (	-50.00, -50.00) GC	8.	52717.453100	AT (	50.00, 0.00) GC
4.	26932.810500	AT (	0.00, 50.00) GC	9.	0.000000	AT (	-50.00, -100.00) GC
5.	50125.472700	AT (	-50.00, 0.00) GC	10.	19036.449200	AT (	-50.00, 50.00) GC

*** SOURCE QU1P3SQ1 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU1ALL ***

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	42348.937500	AT (	0.00, -50.00) GC	6.	62750.433600	AT (	-100.00, -50.00) GC
2.	66662.304700	AT (	0.00, 0.00) GC	7.	25951.209000	AT (	0.00, -100.00) GC
3.	59670.082000	AT (	-50.00, -50.00) GC	8.	39474.953100	AT (	50.00, 0.00) GC
4.	79352.585900	AT (	0.00, 50.00) GC	9.	29689.283200	AT (	-50.00, -100.00) GC
5.	121445.070000	AT (	-50.00, 0.00) GC	10.	151107.859000	AT (	-50.00, 50.00) GC

*** SOURCE QU1P3SQ2 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SGOU1ALL ***

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	56096.683600	AT (	0.00, -50.00) GC	6.	41054.203100	AT (	-100.00, -50.00) GC
2.	106175.094000	AT (	0.00, 0.00) GC	7.	25497.726600	AT (	0.00, -100.00) GC
3.	48101.960900	AT (	-50.00, -50.00) GC	8.	69572.867200	AT (	50.00, 0.00) GC
4.	168507.188000	AT (	0.00, 50.00) GC	9.	22292.418000	AT (	-50.00, -100.00) GC
5.	0.000000	AT (	-50.00, 0.00) GC	10.	0.000000	AT (	-50.00, 50.00) GC

*** RECEPTOR TYPES: GC = GRIDCART
 GP = GRIDPOLR
 DC = DISCCART
 DP = DISCPOLR
 BD = BOUNDARY

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*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 84

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** SOURCE QU1P3SQ3 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SG0U1ALL ***

** CONC OF POLL1 IN MICROGRAMS/M**3

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	46286.113300	AT (	0.00, -50.00) GC	6.	146008.234000	AT (	-100.00, -50.00) GC
2.	44278.722700	AT (	0.00, 0.00) GC	7.	41588.429700	AT (	0.00, -100.00) GC
3.	76433.367200	AT (	-50.00, -50.00) GC	8.	31054.894500	AT (	50.00, 0.00) GC
4.	36201.355500	AT (	0.00, 50.00) GC	9.	65076.273400	AT (	-50.00, -100.00) GC
5.	67227.750000	AT (	-50.00, 0.00) GC	10.	47612.500000	AT (	-50.00, 50.00) GC

*** SOURCE QU1P3SQ4 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SG0U1ALL ***

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	74161.726600	AT (	0.00, -50.00) GC	6.	0.000000	AT (	-100.00, -50.00) GC
2.	76013.515600	AT (	0.00, 0.00) GC	7.	48735.765600	AT (	0.00, -100.00) GC
3.	136049.328000	AT (	-50.00, -50.00) GC	8.	44214.625000	AT (	50.00, 0.00) GC
4.	54519.937500	AT (	0.00, 50.00) GC	9.	75062.328100	AT (	-50.00, -100.00) GC
5.	140161.109000	AT (	-50.00, 0.00) GC	10.	75972.312500	AT (	-50.00, 50.00) GC

*** SOURCE QU1P3SQ5 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SG0U1ALL ***

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	75589.125000	AT (	0.00, -50.00) GC	6.	63251.863300	AT (	-100.00, -50.00) GC
2.	104583.375000	AT (	0.00, 0.00) GC	7.	28175.996100	AT (	0.00, -100.00) GC
3.	73213.484400	AT (	-50.00, -50.00) GC	8.	41234.734400	AT (	50.00, 0.00) GC
4.	47572.535200	AT (	0.00, 50.00) GC	9.	27805.566400	AT (	-50.00, -100.00) GC
5.	0.000000	AT (	-50.00, 0.00) GC	10.	43191.308600	AT (	-50.00, 50.00) GC

*** SOURCE QU1P1T4 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SG0U1ALL ***

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	74891.281300	AT (	0.00, -50.00) GC	6.	35676.820300	AT (	-100.00, -50.00) GC
2.	89247.398400	AT (	0.00, 0.00) GC	7.	52433.023400	AT (	0.00, -100.00) GC
3.	57049.226600	AT (	-50.00, -50.00) GC	8.	0.000000	AT (	50.00, 0.00) GC
4.	56589.168000	AT (	0.00, 50.00) GC	9.	37776.261700	AT (	-50.00, -100.00) GC
5.	59920.367200	AT (	-50.00, 0.00) GC	10.	43294.968800	AT (	-50.00, 50.00) GC

*** RECEPTOR TYPES: GC = GRIDCART
 GP = GRIDPOLR
 DC = DISCCART
 DP = DISCPOLR
 BD = BOUNDARY

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*** ISCLT2 - VERSION 93109 ***

*** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***

07/16/93

*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***

15:11:18

PAGE 85

** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** SOURCE OUTPUT: CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: SG01ALL ***

** CONC OF POLL1 IN MICROGRAMS/M**3

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	50160.101600	AT (	0.00, -50.00) GC	6.	21502.707000	AT (	-100.00, -50.00) GC
2.	0.000000	AT (	0.00, 0.00) GC	7.	16695.691400	AT (	0.00, -100.00) GC
3.	36181.058600	AT (	-50.00, -50.00) GC	8.	128679.164000	AT (	50.00, 0.00) GC
4.	56628.418000	AT (	0.00, 50.00) GC	9.	13320.614300	AT (	-50.00, -100.00) GC
5.	60658.043000	AT (	-50.00, 0.00) GC	10.	26574.306600	AT (	-50.00, 50.00) GC

*** RECEPTOR TYPES: GC = GRIDCART
GP = GRIDPOLR
DC = DISCCART
DP = DISCPOLR
BD = BOUNDARY

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*** ISCLT2 - VERSION 93109 *** *** HOT SPOT MODELING FOR MAXIMUM ON SITE CONCENTRATIONS USING 50 METER ***
*** RECEPTOR GRID AND 1987 METEOROLOGICAL DATA FOR CURRENT SCENARIO ***
MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

07/16/93
15:11:18
PAGE 86

*** Message Summary For ISC2 Model Execution ***

----- Summary of Total Messages -----

A Total of	0 Fatal Error Message(s)
A Total of	0 Warning Message(s)
A Total of	0 Informational Message(s)

***** FATAL ERROR MESSAGES *****
*** NONE ***

***** WARNING MESSAGES *****
*** NONE ***

*** ISCLT2 Finishes Successfully ***

0355

TABLE OF CONTENTS (Continued)

	<u>Page</u>
E.2.1.8 Clearwell Contents Data Sources	E-2-4
E.2.1.9 Surface Soil Data Sources	E-2-4
E.2.1.10 Background Sources	E-2-4
E.2.2 Data Analysis	E-2-5
E.2.2.1 Data Validation	E-2-5
E.2.2.2 Concentration Term	E-2-6
E.2.2.2.1 Determination of UCL/Max for Each Data Set	E-2-7
E.2.2.2.2 Determination of Final Concentration Term	E-2-7
E.2.3 Identification of Constituents of Potential Concern (CPCs)	E-2-8
E.2.3.1 Methodology	E-2-8
E.2.3.1.1 Comparison to Background	E-2-8
E.2.3.1.2 Toxicological Screening	E-2-9
E.2.3.2 Results of Selecting CPCs	E-2-10
E.2.3.2.1 Surface Soil	E-2-10
E.2.3.2.2 Waste Pit 1	E-2-10
E.2.3.2.3 Waste Pit 2	E-2-10
E.2.3.2.4 Waste Pit 3	E-2-10
E.2.3.2.5 Waste Pit 4	E-2-10
E.2.3.2.6 Waste Pit 5	E-2-11
E.2.3.2.7 Waste Pit 6	E-2-11
E.2.3.2.8 Burn Pit	E-2-11
E.2.3.2.9 Clearwell	E-2-11
E.3.0 Human Exposure Assessment	E-3-1
E.3.1 Deviations from the Risk Assessment Work Plan Addendum	E-3-2
E.3.1.1 Exposure Scenarios and Receptors	E-3-2
E.3.1.2 Exposure Input Parameters	E-3-2
E.3.1.3 Exposure Estimation and Methodologies	E-3-3
E.3.2 Characterization of Exposure Setting	E-3-3
E.3.2.1 Climate and Meteorology	E-3-3
E.3.2.2 Topography and Surface Hydrology	E-3-4
E.3.2.3 Soil and Geology	E-3-5
E.3.2.4 Groundwater	E-3-5
E.3.2.5 Vegetation and Wildlife	E-3-6
E.3.2.6 Demography	E-3-7
E.3.2.7 Land Use	E-3-8
E.3.2.8 Future Land Use	E-3-8

TABLE OF CONTENTS (Continued)

	<u>Page</u>
E.3.2.9 Critical Subpopulations	E-3-9
E.3.3 Conceptual Site Model	E-3-10
E.3.3.1 Conceptual Site Model - Current Source Term	E-3-11
E.3.3.1.1 Release Mechanisms	E-3-12
E.3.3.1.2 Transport/Exposure Media	E-3-13
E.3.3.1.3 Exposure Mechanisms and Exposure Routes	E-3-14
E.3.3.1.4 Receptors	E-3-15
E.3.3.1.5 Complete Exposure Pathways	E-3-17
E.3.3.1.6 Exposures Under Current Land Use With Access Controls	E-3-17
E.3.3.1.7 Exposures Under Current Land Use Without Access Controls	E-3-18
E.3.3.2 Conceptual Site Model - Future Source Term	E-3-19
E.3.3.2.1 Release Mechanisms	E-3-20
E.3.3.2.2 Transport/Exposure Media	E-3-21
E.3.3.2.3 Exposure Mechanisms and Exposure Routes	E-3-23
E.3.3.2.4 Receptors	E-3-24
E.3.3.2.5 Complete Exposure Pathways	E-3-25
E.3.3.2.6 Exposures Under Current Land Use Without Access Controls	E-3-25
E.3.3.2.7 Exposures Under Future Land Use	E-3-28
E.3.4 Exposure Point Concentrations	E-3-30
E.3.4.1. Surface Soil	E-3-31
E.3.4.1.1 Radioactive Contaminants	E-3-31
E.3.4.1.2 Chemical Contaminants	E-3-31
E.3.4.2 Exposed Waste Pit Material	E-3-31
E.3.4.2.1 Radioactive Contaminants	E-3-32
E.3.4.2.2 Chemical Contaminants	E-3-32
E.3.4.3 Waste Pits 4 Material	E-3-32
E.3.4.3.1 Radioactive Contaminants	E-3-32
E.3.4.3.2 Chemical Contaminants	E-3-33
E.3.4.4 Buried Pit Materials	E-3-33
E.3.4.5 On-Property Surface Water	E-3-33
E.3.4.5.1 Radioactive Contaminants	E-3-34
E.3.4.5.2 Chemical Contaminants	E-3-34
E.3.4.6 Off-Property Surface Water	E-3-34
E.3.4.6.1 Radioactive Contaminants	E-3-34

TABLE OF CONTENTS (Continued)

	<u>Page</u>
E.3.4.6.2 Chemical Contaminants	E-3-34
E.3.4.7 Sediment	E-3-34
E.3.4.7.1 Radioactive Contaminants	E-3-34
E.3.4.7.2 Chemical Contaminants	E-3-35
E.3.4.8 Groundwater	E-3-35
E.3.4.8.1 Radioactive Contaminants	E-3-36
E.3.4.8.2 Chemical Contaminants	E-3-36
E.3.4.9 Air	E-3-36
E.3.4.9.1 Radioactive Contaminants	E-3-37
E.3.4.9.2 Chemical Contaminants	E-3-37
E.3.5 Quantification of Exposure	E-3-37
E.3.5.1 Equations Quantifying Intakes and Exposures to Soil or Sediment	E-3-38
E.3.5.1.1 Incidental Ingestion	E-3-38
E.3.5.1.2 Dermal Contact	E-3-39
E.3.5.1.3 Direct Radiation Exposure	E-3-39
E.3.5.2 Equations Quantifying Intakes and Exposures from Water	E-3-40
E.3.5.2.1 Water Ingestion Pathway	E-3-40
E.3.5.2.2 Volatiles Released by Showering and Other Household Water Uses	E-3-40
E.3.5.2.3 Dermal Contact While Bathing or Swimming	E-3-41
E.3.5.3 Equations Quantifying Intakes and Exposures from Inhalation	E-3-42
E.3.5.4 Equations Quantifying Intakes and Exposures from Food	E-3-42
E.3.5.4.1 Vegetable and Fruit Ingestion	E-3-43
E.3.5.4.2 Beef Ingestion	E-3-45
E.3.5.4.3 Milk Consumption	E-3-47
E.3.5.4.4 Fish Ingestion	E-3-48
E.3.5.5 Indoor Radon Exposures	E-3-49
E.3.5.6 Quantification of Intakes and Exposures from Multiple Pathways	E-3-50
E.3.5.7 Scenario-Specific Assumptions and Exposure Parameters	E-3-50
E.3.5.7.1 Exposure Duration (ED)	E-3-51
E.3.5.7.2 Exposure Frequency	E-3-51
E.3.5.7.3 Exposure Time	E-3-52
E.3.5.7.4 Inhalation Rates	E-3-53
E.3.5.7.5 Soil Ingestion Rates	E-3-53
E.3.5.7.6 Water Ingestion Rates	E-3-54

TABLE OF CONTENTS (Continued)

	<u>Page</u>
E.3.5.7.7 Food Consumption	E-3-55
E.3.5.7.8 Body Weights	E-3-55
E.3.5.7.9 Surface Areas	E-3-56
E.3.5.7.10 Adherence Factors	E-3-56
E.3.5.7.11 Averaging Times	E-3-56
E.3.6 Summary of Exposure Assessment	E-3-56
E.4.0 Toxicity Assessment	E-4-1
E.4.1 Toxicity Information for Contamination of Potential Concern	E-4-2
E.4.1.1 Radiocarcinogens	E-4-2
E.4.1.2 Chemical Carcinogens	E-4-4
E.4.1.3 Noncarcinogenic Chemicals	E-4-6
E.4.1.4 Dermal Reference Doses and Cancer Slope Factors	E-4-7
E.4.2 Uncertainty Analysis for Toxicity Assessment	E-4-8
E.4.3 Toxicity Profiles	E-4-11
E.4.3.1 Acenaphthylene	E-4-11
E.4.3.1.1 Noncancer Toxicity	E-4-11
E.4.3.1.2 Carcinogenicity	E-4-11
E.4.3.2 Acetone	E-4-12
E.4.3.2.1 Noncancer Toxicity	E-4-12
E.4.3.2.2 Carcinogenicity	E-4-12
E.4.3.3 Ammonia	E-4-12
E.4.3.3.1 Noncancer Toxicity	E-4-12
E.4.3.3.2 Carcinogenicity	E-4-13
E.4.3.4 Antimony	E-4-13
E.4.3.4.1 Pharmacokinetics	E-4-13
E.4.3.4.2 Noncancer Toxicity	E-4-13
E.4.3.4.3 Carcinogenicity	E-4-14
E.4.3.5 Arsenic	E-4-14
E.4.3.5.1 Pharmacokinetics	E-4-14
E.4.3.5.2 Noncancer Toxicity	E-4-14
E.4.3.5.3 Carcinogenicity	E-4-15
E.4.3.6 Barium	E-4-15
E.4.3.6.1 Noncancer Toxicity	E-4-15
E.4.3.6.2 Carcinogenicity	E-4-16
E.4.3.7 Benzene	E-4-16
E.4.3.7.1 Noncancer Toxicity	E-4-16

TABLE OF CONTENTS
(Continued)

	<u>Page</u>
E.4.3.7.2 Carcinogenicity	E-4-16
E.4.3.8 Benzoic Acid	E-4-16
E.4.3.8.1 Noncancer Toxicity	E-4-16
E.4.3.8.2 Carcinogenicity	E-4-16
E.4.3.9 Beryllium	E-4-17
E.4.3.9.1 Noncancer Toxicity	E-4-17
E.4.3.9.2 Carcinogenicity	E-4-17
E.4.3.10 Bis(2-ethylhexyl)phthalate (di[2-ethylhexyl]phthalate)	E-4-17
E.4.3.10.1 Noncancer Toxicity	E-4-17
E.4.3.10.2 Carcinogenicity	E-4-17
E.4.3.11 Boron	E-4-18
E.4.3.11.1 Noncancer Toxicity	E-4-18
E.4.3.11.2 Carcinogenicity	E-4-18
E.4.3.12 Bromodichloromethane	E-4-18
E.4.3.12.1 Noncancer Toxicity	E-4-18
E.4.3.12.2 Carcinogenicity	E-4-18
E.4.3.13 2-Butanone (Methyl Ethyl Ketone)	E-4-19
E.4.3.13.1 Noncancer Toxicity	E-4-19
E.4.3.13.2 Carcinogenicity	E-4-19
E.4.3.14 Cadmium	E-4-19
E.4.3.14.1 Pharmacokinetics	E-4-19
E.4.3.14.2 Noncancer Toxicity	E-4-20
E.4.3.14.3 Carcinogenicity	E-4-20
E.4.3.15 Carbon Tetrachloride	E-4-20
E.4.3.15.1 Noncancer Toxicity	E-4-20
E.4.3.15.2 Carcinogenicity	E-4-21
E.4.3.16 Chlorobenzene	E-4-21
E.4.3.16.1 Noncancer Toxicity	E-4-21
E.4.3.16.2 Carcinogenicity	E-4-21
E.4.3.17 Chloroform	E-4-21
E.4.3.17.1 Noncancer Toxicity	E-4-21
E.4.3.17.2 Carcinogenicity	E-4-22
E.4.3.18 4-Chloro-3-methylphenol (p-chloro-m-cresol)	E-4-22
E.4.3.18.1 Noncancer Toxicity	E-4-22
E.4.3.18.2 Carcinogenicity	E-4-22
E.4.3.19 2-Chlorophenol	E-4-22

0361

TABLE OF CONTENTS (Continued)

	<u>Page</u>
E.4.3.19.1 Noncancer Toxicity	E-4-22
E.4.3.19.2 Carcinogenicity	E-4-22
E.4.3.20 4-Chlorophenyl Phenyl Ether (4-Chlorodiphenyl Ether)	E-4-23
E.4.3.20.1 Noncancer Toxicity	E-4-23
E.4.3.20.2 Carcinogenicity	E-4-23
E.4.3.21 3-Chloropropene (Allyl Chloride)	E-4-23
E.4.3.21.1 Noncancer Toxicity	E-4-23
E.4.3.21.2 Carcinogenicity	E-4-24
E.4.3.22 Chromium	E-4-24
E.4.3.22.1 Noncancer Toxicity	E-4-24
E.4.3.22.2 Carcinogenicity	E-4-25
E.4.3.23 Chlordane	E-4-25
E.4.3.23.1 Pharmacokinetics	E-4-25
E.4.3.23.2 Noncancer Toxicity	E-4-25
E.4.3.23.3 Carcinogenicity	E-4-26
E.4.3.24 Cobalt	E-4-26
E.4.3.24.1 Noncancer Toxicity	E-4-26
E.4.3.24.2 Carcinogenicity	E-4-28
E.4.3.25 Copper	E-4-28
E.4.3.25.1 Noncancer Toxicity	E-4-28
E.4.3.25.2 Carcinogenicity	E-4-28
E.4.3.26 Cyanide	E-4-28
E.4.3.26.1 Noncancer Toxicity	E-4-28
E.4.3.26.2 Carcinogenicity	E-4-29
E.4.3.27 4,4-Dichlorodiphenyltrichloroethane (DDT)	E-4-29
E.4.3.27.1 Noncancer Toxicity	E-4-29
E.4.3.27.2 Carcinogenicity	E-4-29
E.4.3.28 Dibenzofuran	E-4-29
E.4.3.28.1 Noncancer Toxicity	E-4-29
E.4.3.28.2 Carcinogenicity	E-4-29
E.4.3.29 Dibenzo-p-dioxins/Dibenzofurans	E-4-30
E.4.3.29.1 Noncancer Toxicity	E-4-30
E.4.3.29.2 Carcinogenicity	E-4-30
E.4.3.30 Di-n-butylphthalate (dibutylphthalate)	E-4-31
E.4.4.30.1 Noncancer Toxicity	E-4-31
E.4.4.30.2 Carcinogenicity	E-4-31

TABLE OF CONTENTS (Continued)

	<u>Page</u>
E.4.3.31 3,3'-Dichlorobenzidine	E-4-31
E.4.3.31.1 Noncancer Toxicity	E-4-31
E.4.3.31.2 Carcinogenicity	E-4-31
E.4.3.32 Dichlorofluoromethane	E-4-32
E.4.3.32.1 Noncancer Toxicity	E-4-32
E.4.3.32.2 Carcinogenicity	E-4-32
E.4.3.33 1,1-Dichloroethane	E-4-32
E.4.3.33.1 Noncancer Toxicity	E-4-32
E.4.3.32.2 Carcinogenicity	E-4-33
E.4.3.34 1,2-Dichloroethane	E-4-33
E.4.3.34.1 Noncancer Toxicity	E-4-33
E.4.3.34.2 Carcinogenicity	E-4-33
E.4.3.35 1,1-Dichloroethene	E-4-33
E.4.3.35.1 Noncancer Toxicity	E-4-33
E.4.3.35.2 Carcinogenicity	E-4-33
E.4.3.36 cis-1,2-Dichloroethene (c-1,2-Dichloroethylene)	E-4-34
E.4.3.36.1 Noncancer Toxicity	E-4-34
E.4.3.36.2 Carcinogenicity	E-4-34
E.4.4.37 trans-1,2-Dichloroethene (t-1,2-Dichloroethylene)	E-4-34
E.4.3.37.1 Noncancer Toxicity	E-4-34
E.4.3.37.2 Carcinogenicity	E-4-35
E.4.3.38 Dichlorofluoromethane	E-4-35
E.4.3.38.1 Noncancer Toxicity	E-4-35
E.4.3.38.2 Carcinogenicity	E-4-35
E.4.3.39 Diethyl Phthalate	E-4-35
E.4.3.39.1 Noncancer Toxicity	E-4-35
E.4.3.39.2 Carcinogenicity	E-4-36
E.4.3.40 2,4-Dimethylphenol	E-4-36
E.4.3.40.1 Noncancer Toxicity	E-4-36
E.4.3.40.2 Carcinogenicity	E-4-36
E.4.3.41 Di-n-octylphthalate	E-4-36
E.4.3.41.1 Noncancer Toxicity	E-4-36
E.4.3.41.2 Carcinogenicity	E-4-36
E.4.3.42 1,4-Dioxane	E-4-37
E.4.3.42.1 Noncancer Toxicity	E-4-37
E.4.3.42.2 Carcinogenicity	E-4-37

TABLE OF CONTENTS (Continued)

	<u>Page</u>
E.4.3.43 Ethyl Benzene	E-4-37
E.4.3.43.1 Noncancer Toxicity	E-4-37
E.4.3.43.2 Carcinogenicity	E-4-38
E.4.3.44 Ethyl Parathion (Parathion)	E-4-38
E.4.3.44.1 Noncancer Toxicity	E-4-38
E.4.3.44.2 Carcinogenicity	E-4-38
E.4.3.45 2-Hexanone (methyl n-butyl ketone)	E-4-38
E.4.3.45.1 Noncancer Toxicity	E-4-38
E.4.3.45.2 Carcinogenicity	E-4-38
E.4.3.46 Isobutyl Alcohol	E-4-39
E.4.3.46.1 Noncancer Toxicity	E-4-39
E.4.3.46.2 Carcinogenicity	E-4-39
E.4.3.47 Lead	E-4-39
E.4.3.47.1 Pharmacokinetics	E-4-39
E.4.3.47.2 Noncancer Toxicity	E-4-39
E.4.3.47.3 Carcinogenicity	E-4-41
E.4.3.48 Malathion	E-4-41
E.4.3.48.1 Noncancer Toxicity	E-4-41
E.4.3.48.2 Carcinogenicity	E-4-42
E.4.3.49 Manganese	E-4-42
E.4.3.49.1 Noncancer Toxicity	E-4-42
E.4.3.49.2 Carcinogenicity	E-4-43
E.4.3.50 Mercury	E-4-43
E.4.3.50.1 Pharmacokinetics	E-4-43
E.4.3.50.2 Noncancer Toxicity	E-4-43
E.4.3.50.3 Carcinogenicity	E-4-44
E.4.3.51 Methylene Chloride	E-4-44
E.4.3.51.1 Noncancer Toxicity	E-4-44
E.4.3.51.2 Carcinogenicity	E-4-45
E.4.3.52 2-Methylnaphthalene	E-4-45
E.4.3.52.1 Noncancer Toxicity	E-4-45
E.4.3.52.2 Carcinogenicity	E-4-45
E.4.3.53 Methyl Parathion	E-4-45
E.4.3.53.1 Noncancer Toxicity	E-4-45
E.4.3.53.2 Carcinogenicity	E-4-45
E.4.3.54 4-Methyl-2-Pentanone (Methyl Isobutyl Ketone)	E-4-46

0364

TABLE OF CONTENTS
(Continued)

	<u>Page</u>
E.4.3.54.1 Noncancer Toxicity	E-4-46
E.4.3.54.2 Carcinogenicity	E-4-46
E.4.3.55 2-Methylphenol (o-cresol)	E-4-46
E.4.3.55.1 Noncancer Toxicity	E-4-46
E.4.3.55.2 Carcinogenicity	E-4-47
E.4.3.56 3-Methylphenol	E-4-47
E.4.3.56.1 Noncancer Toxicity	E-4-47
E.4.3.56.2 Carcinogenicity	E-4-47
E.4.3.57 4-Methylphenol (p-cresol)	E-4-47
E.4.3.57.1 Noncancer Toxicity	E-4-47
E.4.3.57.2 Carcinogenicity	E-4-48
E.4.3.58 Molybdenum	E-4-48
E.4.3.58.1 Noncancer Toxicity	E-4-48
E.4.3.58.2 Carcinogenicity	E-4-48
E.4.3.59 Neptunium	E-4-48
E.4.3.59.1 Pharmacokinetics	E-4-49
E.4.3.59.2 Noncancer Toxicity	E-4-49
E.4.3.59.3 Carcinogenicity	E-4-49
E.4.3.60 Nickel	E-4-50
E.4.3.60.1 Noncancer Toxicity	E-4-50
E.4.3.60.2 Carcinogenicity	E-4-50
E.4.3.61 Nitrate Nitrogen, Nitrite Nitrogen	E-4-51
E.4.3.61.1 Noncancer Toxicity	E-4-51
E.4.3.61.2 Carcinogenicity	E-4-51
E.4.3.62 N-nitrosodiphenylamine (Diphenylnitrosamine)	E-4-51
E.4.3.62.1 Noncancer Toxicity	E-4-51
E.4.3.62.2 Carcinogenicity	E-4-51
E.4.3.63 4-Nitroaniline	E-4-51
E.4.3.63.1 Pharmacokinetics	E-4-51
E.4.3.63.2 Noncancer Toxicity	E-4-52
E.4.3.63.3 Carcinogenicity	E-4-52
E.4.3.64 4-Nitrophenol	E-4-52
E.4.3.64.1 Pharmacokinetics	E-4-52
E.4.3.64.2 Noncancer Toxicity	E-4-52
E.4.3.64.3 Carcinogenicity	E-4-52
E.4.3.65 Pentachlorophenol	E-4-52

TABLE OF CONTENTS (Continued)

	<u>Page</u>
E.4.3.65.1 Noncancer Toxicity	E-4-52
E.4.3.65.2 Carcinogenicity	E-4-52
E.4.3.66 Phenol	E-4-53
E.4.3.66.1 Noncancer Toxicity	E-4-53
E.4.3.66.2 Carcinogenicity	E-4-53
E.4.3.67 Plutonium	E-4-53
E.4.3.67.1 Pharmacokinetics	E-4-54
E.4.3.67.2 Noncancer Toxicity	E-4-54
E.4.3.67.3 Carcinogenicity	E-4-55
E.4.3.68 Polyaromatic Hydrocarbons	E-4-55
E.4.3.68.1 Pharmacokinetics	E-4-55
E.4.3.68.2 Noncancer Toxicity	E-4-56
E.4.3.68.3 Carcinogenicity	E-4-58
E.4.3.69 Polychlorinated Biphenyls	E-4-59
E.4.3.69.1 Noncancer Toxicity	E-4-59
E.4.3.69.2 Carcinogenicity	E-4-59
E.4.3.70 2-Propanol (Isopropyl Alcohol)	E-4-60
E.4.3.70.1 Noncancer Toxicity	E-4-60
E.4.3.70.2 Carcinogenicity	E-4-60
E.4.3.71 Radium	E-4-60
E.4.3.71.1 Noncancer Toxicity	E-4-60
E.4.3.71.2 Carcinogenicity	E-4-60
E.4.3.72 Radon and Progeny	E-4-63
E.4.3.72.1 Noncancer Toxicity	E-4-63
E.4.3.72.2 Carcinogenicity	E-4-63
E.4.3.73 Selenium	E-4-65
E.4.3.73.1 Noncancer Toxicity	E-4-65
E.4.3.73.2 Carcinogenicity	E-4-66
E.4.3.74 Silver	E-4-66
E.4.3.74.1 Pharmacokinetics	E-4-66
E.4.3.74.2 Noncancer Toxicity	E-4-66
E.4.3.74.3 Carcinogenicity	E-4-67
E.4.3.75 Strontium	E-4-67
E.4.3.75.1 Pharmacokinetics	E-4-67
E.4.3.75.2 Chemical Toxicity	E-4-67
E.4.3.75.3 Carcinogenicity	E-4-68

TABLE OF CONTENTS
(Continued)

	<u>Page</u>
E.4.3.76 Styrene	E-4-69
E.4.3.76.1 Noncancer Toxicity	E-4-69
E.4.3.76.2 Carcinogenicity	E-4-69
E.4.3.77 Technetium	E-4-69
E.4.3.77.1 Pharmacokinetics	E-4-70
E.4.3.77.2 Noncancer Toxicity	E-4-70
E.4.3.77.3 Carcinogenicity	E-4-71
E.4.3.78 1,1,2,2-Tetrachloroethane (Tetrachloroethane)	E-4-71
E.4.3.78.1 Noncancer Toxicity	E-4-71
E.4.3.78.2 Carcinogenicity	E-4-71
E.4.3.79 Tetrachloroethene (Tetrachloroethylene)	E-4-71
E.4.3.79.1 Noncancer Toxicity	E-4-71
E.4.3.79.2 Carcinogenicity	E-4-72
E.4.3.80 Thallium, Soluble Salts	E-4-72
E.4.3.80.1 Noncancer Toxicity	E-4-72
E.4.3.80.2 Carcinogenicity	E-4-72
E.4.3.81 Thorium	E-4-72
E.4.3.81.1 Noncancer Toxicity	E-4-72
E.4.3.81.2 Carcinogenicity	E-4-73
E.4.3.82 Inorganic Tin	E-4-75
E.4.3.82.1 Pharmacokinetics	E-4-75
E.4.3.82.2 Noncancer Toxicity	E-4-75
E.4.3.82.3 Carcinogenicity	E-4-76
E.4.3.83 Toluene	E-4-76
E.4.3.83.1 Noncancer Toxicity	E-4-76
E.4.3.83.2 Carcinogenicity	E-4-76
E.4.3.84 Tributyl Phosphate	E-4-76
E.4.3.84.1 Noncancer Toxicity	E-4-76
E.4.3.84.2 Carcinogenicity	E-4-77
E.4.3.85 1,1,1-Trichloroethane	E-4-77
E.4.3.85.1 Noncancer Toxicity	E-4-77
E.4.3.85.2 Carcinogenicity	E-4-77
E.4.3.86 Trichloroethene	E-4-77
E.4.3.86.1 Noncancer Toxicity	E-4-77
E.4.3.86.2 Carcinogenicity	E-4-78
E.4.3.87 Trichlorofluoromethane	E-4-78

TABLE OF CONTENTS
(Continued)

4787

	<u>Page</u>
E.4.3.87.1 Noncancer Toxicity	E-4-78
E.4.3.87.2 Carcinogenicity	E-4-79
E.4.3.88 1,1,2-Trichloro-1,2,2-trifluoromethane	E-4-79
E.4.3.88.1 Noncancer Toxicity	E-4-79
E.4.3.88.2 Carcinogenicity	E-4-79
E.4.3.89 2,4,5-Trichlorophenol	E-4-79
E.4.3.89.1 Pharmacokinetics	E-4-79
E.4.3.89.2 Noncancer Effects	E-4-79
E.4.3.89.3 Carcinogenicity	E-4-80
E.4.3.90 Uranium	E-4-80
E.4.3.90.1 Noncancer Toxicity	E-4-80
E.4.3.90.2 Carcinogenicity	E-4-80
E.4.3.91 Vanadium	E-4-84
E.4.3.91.1 Noncancer Toxicity	E-4-84
E.4.3.91.2 Carcinogenicity	E-4-84
E.4.3.92 Vinyl Chloride	E-4-84
E.4.3.92.1 Noncancer Toxicity	E-4-84
E.4.3.92.2 Carcinogenicity	E-4-85
E.4.3.93 Xylenes	E-4-85
E.4.3.93.1 Noncancer Toxicity	E-4-85
E.4.3.93.2 Carcinogenicity	E-4-85
E.4.3.94 Zinc	E-4-86
E.4.3.94.1 Pharmacokinetics	E-4-86
E.4.3.94.2 Noncancer Toxicity	E-4-86
E.4.3.94.3 Carcinogenicity	E-4-86
E.5.0 Health Risk Characterization	E-5-1
E.5.1 Risk Characterization Methodology	E-5-1
E.5.1.1 Radiocarcinogenic Risks	E-5-1
E.5.1.1.1 Methodology for Internal Radiation Exposures	E-5-1
E.5.1.1.2 Methodology for External Radiation Exposures	E-5-2
E.5.1.2 Chemical Risks	E-5-2
E.5.1.2.1 Methodology for Carcinogens	E-5-2
E.5.1.2.2 Methodology for Noncarcinogens	E-5-3
E.5.1.3 Exposures to Multiple Constituents	E-5-3
E.5.1.4 Multiple Pathways	E-5-4
E.5.2 Risk Estimates for Current Site Conditions	E-5-4

TABLE OF CONTENTS
(Continued)

	<u>Page</u>
E.5.2.1 On-Property Exposures of Off-Property Receptors	E-5-4
E.5.2.1.1 Trespassing Child	E-5-5
E.5.2.1.2 Visitor	E-5-6
E.5.2.2 Off-Property Exposures	E-5-6
E.5.2.2.1 Off-Property Resident Adult Farmer	E-5-7
E.5.2.2.2 Off-Property User of Meat and Dairy Products	E-5-7
E.5.2.2.3 Composite Off-Property Resident	E-5-8
E.5.2.3 Summary of Health Effects Under the Current Land Use Scenarios	E-5-9
E.5.3 Risk Estimates for Future Site Conditions	E-5-10
E.5.3.1 On-Property Exposures of Off-Property Residents	E-5-10
E.5.3.2 Off-Property Exposures	E-5-11
E.5.3.2.1 Off-Property Resident Adult	E-5-11
E.5.3.2.2 Great Miami River User	E-5-12
E.5.3.2.3 Off-Property User of Meat and Dairy Products	E-5-13
E.5.3.2.4 Composite Off-Property Resident	E-5-13
E.5.3.3 On-Property Exposures	E-5-14
E.5.3.3.1 RME Resident Adult Farmer	E-5-14
E.5.3.3.2 CT Resident Adult Farmer	E-5-15
E.5.3.3.3 RME Resident Child	E-5-16
E.5.3.3.4 Home Builder	E-5-17
E.5.3.4 Summary of Health Effects Under Future Site Conditions	E-5-18
E.5.4 Summary of Health Risk Characterization	E-5-19
E.6.0 Uncertainties	E-6-1
E.6.1 Terminology	E-6-1
E.6.2 Sources of Uncertainty in Operable Unit 1	E-6-3
E.6.2.1 Selection of Constituents of Potential Concern	E-6-4
E.6.2.2 Uncertainty in Exposure Assessment	E-6-5
E.6.2.2.1 Exposure Point Concentrations	E-6-5
E.6.2.2.2 Determination of Land Uses	E-6-8
E.6.2.2.3 Selection of Receptors	E-6-8
E.6.2.2.4 Determination of Exposure Factors	E-6-9
E.6.2.3 Toxicity Assessment	E-6-10
E.6.2.4 Risk Characterization	E-6-13
E.6.3 Summary of Uncertainties in Operable Unit 1 Baseline Risk Assessment	E-6-14
E.7.0 Summary and Comparison to Background	E-7-1
E.7.1 Risk Assessment Summary	E-7-1

TABLE OF CONTENTS
(Continued)

	<u>Page</u>
E.7.2 Risks from Natural Background	E-7-2
E.7.3 Conclusions	E-7-3
References	E-R-1
Attachment I - Background Concentration for Radionuclides and Chemicals at the FEMP	
Attachment II - Screening of Constituents of Potential Concern	
Attachment III - Example Calculations of Intakes and Risks for OU1 Baseline Risk Assessment	
Attachment IV - Risk Calculation Results	

LIST OF FIGURES

<u>Figure</u>	<u>Title</u>	<u>Page</u>
ES-1	Location of Operable Unit 1 Within the FEMP	ES-16
ES-2	Operable Unit 1 Site Map	ES-17
E.1-1	FEMP Site Location Map	E-1-21
E.1-2	Location of Operable Unit 1 Within the FEMP	E-1-22
E.1-3	Land Use Adjacent to the FEMP	E-1-23
E.1-4	Operable Unit 1 Site Map	E-1-24
E.2-1	Principal Decay Scheme of the Uranium Series	E-2-13
E.2-2	Principal Decay Scheme of the Thorium Series	E-2-14
E.3-1	Wind Rose for the FEMP Site Year 1992	E-3-56
E.3-2	Conceptual Model of Current Source Term Configuration	E-3-57
E.3-3	Conceptual Model of Future Source Term Configuration	E-3-58
E.3-4	Receptor Locations Used to Evaluate Air and Groundwater Exposures from OU1	E-3-59
E.5-1	Total Carcinogenic Risk Associated With Groundwater Use	E-5-31

LIST OF TABLES

<u>Table</u>	<u>Title</u>	<u>Page</u>
E.1-1	Operable Unit 1 Unit Description	E-1-22
E.2-1	Data Used for the Operable Unit 1 Risk Assessment	E-2-12
E.2-2	Radiological CPCs in Surface Soil (pCi/g)	E-2-13
E.2-3	Chemical CPCs in Surface Soil (mg/kg)	E-2-14
E.2-4	Radiological CPCs in Waste Pit 1 - Solid Contents (pCi/g)	E-2-15
E.2-5	Chemical CPCs in Waste Pit 1 - Solid Contents (mg/kg)	E-2-16
E.2-6	Radiological CPCs in Waste Pit 2 - Solid Contents (pCi/g)	E-2-19
E.2-7	Chemical CPCs in Waste Pit 2 - Solid Contents (mg/kg)	E-2-20
E.2-8	Radiological CPCs in Waste Pit 3 - Solid Contents (pCi/g)	E-2-23
E.2-9	Chemical CPCs in Waste Pit 3 - Solid Contents (mg/kg)	E-2-24
E.2-10	Radiological CPCs in Waste Pit 4 - Solid Contents (pCi/g)	E-2-27
E.2-11	Chemical CPCs in Waste Pit 4 - Solid Contents (mg/kg)	E-2-28
E.2-12	Radiological CPCs in Waste Pit 5 - Solid Contents (pCi/g)	E-2-32
E.2-13	Chemical CPCs in Waste Pit 5 - Solid Contents (mg/kg)	E-2-33
E.2-14	Radiological CPCs in Waste Pit 5 - Surface Water (pCi/L)	E-2-35
E.2-15	Chemical CPCs in Waste Pit 5 - Surface Water (µg/L)	E-2-36
E.2-16	Radiological CPCs in Waste Pit 6 - Solid Contents (pCi/g)	E-2-37
E.2-17	Chemical CPCs in Waste Pit 6 - Solid Contents (mg/kg)	E-2-38
E.2-18	Radiological CPCs in Waste Pit 6 - Surface Water (pCi/L)	E-2-40
E.2-19	Chemical CPCs in Waste Pit 6 - Surface Water (mg/L)	E-2-41
E.2-20	Radiological CPCs in Waste Burn Pit - Solid Contents (pCi/g)	E-2-42
E.2-21	Chemical CPCs in the Burn Pit - Solid Contents (mg/kg)	E-2-43
E.2-22	Radiological CPCs in the Clearwell - Solid Contents (pCi/g)	E-2-46
E.2-23	Chemical CPCs in the Clearwell - Solid Contents (mg/kg)	E-2-47
E.2-24	Radiological CPCs in the Clearwell - Surface Water (pCi/L)	E-2-49
E.2-25	Chemical CPCs in the Clearwell - Surface Water (µg/L)	E-2-50
E.3-1	Summary of Exposure Pathways Quantitatively Evaluated in Risk Assessment Current Source Term	E-3-58
E.3-2	Summary of Exposure Pathways Quantitatively Evaluated in Risk Assessment Future Source Term	E-3-59
E.3-3	Exposure Point Concentrations All Surface Soil (Including Pit Covers)	E-3-64
E.3-4	Exposure Point Concentrations Exposed Pit Material and Surface Soil Future Source Term	E-3-66
E.3-5	Future Exposure Point Concentrations Pits 1 and 2	E-3-68
E.3-6	Dose Rates at 1 Meter Above Operable Unit 1 Source Pits (mrem/hr)	E-3-71
E.3-7	Exposure Point Concentrations On-Property Surface Water Current Source Term	E-3-72

LIST OF TABLES
(Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
E.3-8	Exposure Point Concentrations On-Property Surface Water Future Source Term	E-3-73
E.3-9	Estimated Exposure Point Concentrations Great Miami River	E-3-74
E.3-10	Estimated Exposure Point Concentrations Paddy's Run Sediment	E-3-75
E.3-11	Maximum Estimated Exposure Point Concentrations On- and Off-Property Groundwater Future Source Term	E-3-76
E.3-12	Estimated Exposure Point Concentrations Air - PM10 Current Source Term	E-3-77
E.3-13	Estimated Exposure Point Concentrations Air - PM10 Future Source Term	E-3-79
E.3-14	Exposure Input Parameters Current Source Term Receptors	E-3-82
E.3-15	Exposure Input Parameters Future Source Term Receptors	E-3-84
E.3-16	Exposure Input Parameters Current Source Term Receptors	E-3-86
E.3-17	Exposure Input Parameters Future Source Term Receptors	E-3-89
E.4-1	Cancer Slope Factors for Operable Unit 1 Radionuclides of Concern Updated: 7/93	E-4-87
E.4-2	Toxicity Values for Operable Unit 1 Chemicals	E-4-89
E.4-3	Dioxin and Furan Toxicity Equivalency Factors	E-4-92
E.4-4	Summary of Relative Potency Factors for Carcinogenic PAHs	E-4-93
E.4-5	Dermal Reference Doses and Cancer Slope Factors for Chemical Constituents of Potential Concern	E-4-94
E.4-6	Dermal Absorption Coefficients and Henry's Law Constants Used in Exposure Model	E-4-97
E.5-1	Total Carcinogenic Risks Current Source Term	E-5-22
E.5-2	Total Hazard Indices Current Source Term	E-5-23
E.5-3	Summary of Total Carcinogenic Risks - Current Source Term - Maximally Exposed Individual	E-5-24
E.5-4	Summary of Total HI - Current Source Term - Maximally Exposed Individuals	E-5-25
E.5-5	Total Carcinogenic Risks and Hazard Indices Future Source Term - Current Land Use On-Property Exposures - Trespassing Child	E-5-26
E.5-6	Total Carcinogenic Risks and Hazard Indices Future Source Term - Current Land Use Off-Property Exposures - RME Resident	E-5-27
E.5-7	Total Radiocarcinogenic Risks Future Source Term - Current Land Use Off-Property Exposures - Great Miami River User	E-5-28
E.5-8	Total Carcinogenic Risks and Hazard Indices Future Source Term - Current Land Use Off-Property User of Meat and Dairy Products	E-5-29
E.5-9	Total Carcinogenic Risks Future Land Use On Property Exposures	E-5-30
E.5-10	Total Hazard Indices Future Land Use On-Property Exposures	E-5-32
E.5-11	Summary of Total Carcinogenic Risks Future Source Term Maximally Exposed Individuals	E-5-33

LIST OF TABLES
(Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
E.5-12	Summary of Total HI - Future Source Term - Maximally Exposed Individual	E-5-34
E.6-1	Uncertainties Associated with Estimated Risks from Operable Unit 1	E-6-16
E.6-3	Toxic Effects (Chemical) Soil Pathways Associated with Future Land Use without Access Controls On-Property Resident/Reasonable Maximum Exposure Natural Background Concentrations	E-6-7
E.7-1	Incremental Lifetime Cancer Risk Summary Current Source Term	E-7-5
E.7-2	Hazard Index Summary Current Source Term	E-7-6
E.7-3	Incremental Lifetime Cancer Risk Summary Future Source Term	E-7-7
E.7-4	Hazard Index Summary Future Source Term	E-7-9
E.7-5	Incremental Lifetime Cancer Risks for Soil Pathways RME Resident Farmer Natural Background Concentrations	E-7-10
E.7-6	Toxic Effects for Soil Pathways RME Resident Farmer Natural Background Concentrations	E-7-11

E.1.0 INTRODUCTION

This appendix contains the Operable Unit 1 Baseline Risk Assessment, which was prepared to support the Operable Unit 1 Remedial Investigation (RI) report. Operable Unit 1 is defined as the waste pit area and includes Waste Pits 1 through 6, the Clearwell, Burn Pit, berms, liners, and soil within the operable unit boundary. The primary objective of this Baseline Risk Assessment is to evaluate and document the potential threats to human health and the environment that may be posed by current and predicted future exposures to contaminants within Operable Unit 1 if no remedial actions are taken beyond those already complete.

The specific objectives of this Baseline Risk Assessment are:

- Estimate the magnitude of potential health risks, as calculated using Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) methodology, associated with Operable Unit 1 if no remedial actions are taken.
- Identify the areas, environmental media, and contaminants that pose the primary health concerns.
- Identify the areas, environmental media, and contaminants that pose little or no threat to human health.
- Identify whether there are data gaps so additional information can be collected in subsequent phases of the Remedial Investigation/Feasibility Study (RI/FS) process to support cleanup decisions.
- Provide a basis for determining whether remediation is necessary at the site.
- Identify specific areas and environmental media for which cleanup is appropriate.
- Present a "baseline" of potential human health risks for the no-action alternative in the FS.
- Provide a basis for determining cleanup levels and criteria.

This Baseline Risk Assessment provides the framework for determining human health risks associated with Operable Unit 1, if no further remedial actions or institutional controls are applied. If risks are deemed unacceptable, the baseline risk assessment is used to develop information necessary to assist in evaluating remedial alternatives.

The following activities/analyses are performed in the Baseline Risk Assessment to develop this information:

- Identification of constituents of potential concern 1
- Identification of significant exposure pathways 2
- Quantification of significant exposures attributable to Operable Unit 1 3
- Estimation of health risks to potential on- and off-site receptors 4
- Characterization of sources and degrees of uncertainty in the risk analysis 5

The Operable Unit 1 RI addresses only the potential risks associated with the contaminant sources, or waste storage areas within the boundaries of Operable Unit 1. Baseline risks associated with contaminants currently found in the surrounding groundwater, surface water, and sediments will be addressed in the Operable Unit 5 RI/FS. Operable Units 2, 3, and 4 will also address the potential for constituent migration from these operable units and the potential impact on environmental media. Thus, while the Operable Unit 1 RI provides information on surrounding media, the baseline risk assessment addresses only the risks posed by contaminants in Operable Unit 1 in order to determine if remediation is required. With the use of fate and transport modeling, the risk assessment will address the potential for Operable Unit 1 to contribute to future contamination in the surrounding media.

The Site-Wide Characterization Report (DOE 1993c) contains detailed information concerning site ecological receptors and any potential impacts the site may have had on these resources. Therefore, risks to ecological resources and any associated impacts will not be addressed in this document. These concerns are within the scope of Operable Unit 5, as specified in the Risk Assessment Work Plan Addendum (DOE 1992a), and agreed to by EPA Region V BTAG in February 1993.

The organization of this Baseline Risk Assessment for Operable Unit 1 is consistent with the four primary steps of the risk assessment process, as described in U.S. Environmental Protection Agency (EPA) guidance. These steps include data compilation and analysis, exposure assessment, toxicity assessment, and risk characterization. The report is organized as follows:

- Section E.1.0 (Introduction) presents general information on the site background and the overall approach used in the Operable Unit 1 Baseline Risk Assessment. 24
- Section E.2.0 (Identification of Constituents of Potential Concern) reviews the data collection effort and evaluates available data to identify contaminants of potential concern for the human health evaluation. 26
- Section E.3.0 (Human Exposure Assessment) describes the exposure setting, potential receptor populations, and relevant exposure pathways; estimates exposure point concentrations (based on the fate and transport assessment presented in Section 5.0 of the RI Report); and quantifies exposure for each receptor population. 29

- Section E.4.0 (Toxicity Assessment) provides human toxicity information for the contaminants detected at Operable Unit 1.
- Section E.5.0 (Health Risk Characterization) presents the methodology and results of the health risk assessment.
- Section E.6.0 (Uncertainties) summarizes the uncertainties associated with selection of constituents of potential concern, exposure and toxicity assessments, and risk characterization for the human health assessment.
- Section E.7.0 (Summary and Comparison to Background) provides a risk summary and a comparison of site risks to background risks due to the presence of inorganic and radiological constituents in native soils.

This appendix contains four attachments. Attachment E.I presents a summary of background concentrations of chemicals in various environmental media. Attachment E.II presents summary statistics for the different data sets used in preparing the Baseline Risk Assessment. Attachment E.III contains receptor-specific intakes for the constituents of potential concern. Attachment E.IV presents calculated chemical-specific risks for all receptor and exposure routes.

E.1.1 OVERVIEW

The Fernald Environmental Management Project (FEMP) is located on 425 hectares (1050 acres) in Hamilton and Butler counties in southwestern Ohio. The Fernald site is approximately 29 kilometers (17 miles) northwest of downtown Cincinnati, Ohio, between the villages of Ross and Fernald (Figure E.1-1). The site became contaminated with radioactive and nonradioactive materials as a result of processing and disposal activities that took place during production at the facility. The U.S. Department of Energy (DOE) is responsible for cleanup under the Environmental Restoration and Waste Management Program. The major goals of this program are to eliminate potential hazards to human health and the environment. The Fernald site is operated by the Fernald Environmental Restoration Management Corporation (FERMCO).

For completion of the RI/FS and implementation of the remedial actions, the site is divided into five study areas, or operable units, as shown in Figure E.1-2:

- Operable Unit 1 - Waste Pit Area
- Operable Unit 2 - Other Waste Units
- Operable Unit 3 - Former production area
- Operable Unit 4 - Silos 1 through 4
- Operable Unit 5 - Environmental Media

Each operable unit is undergoing a separate RI/FS, which characterizes the nature and extent of contamination, evaluates potential risks to human health and the environment, and evaluates potential remedial alternatives for each unit. This Baseline Risk Assessment for Operable Unit 1 addresses

potential human health impacts associated with the waste pit area under current and hypothetical future conditions in the absence of cleanup. The health risk assessment provides a technical basis for determining whether remedial action is warranted and provides a basis for evaluation for remedial alternatives in the event that site remediation is deemed necessary. Potential ecological impacts associated with Operable Unit 1 are addressed in the Site Wide Characterization Report (DOE 1993c) and will be addressed in the Operable Unit 1 FS and the Operable Unit 5 RI.

E.1.1.1 Environmental Compliance Process

The assessment of baseline health risks and environmental impacts for a contaminated site is an important element of the RI/FS process. This process addresses the cleanup of hazardous waste sites under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Four primary evaluation documents constitute the RI/FS for Operable Unit 1:

- The RI, which presents site characterization results and addresses the nature and extent of contamination
- This Baseline Risk Assessment, which uses information from the RI to estimate human health impacts that could occur if no cleanup actions are taken
- The FS, which develops and evaluates cleanup alternatives based on the results of the Baseline Risk Assessment and the various response actions that might be appropriate for the contaminated locations and media at the site
- The proposed plan (PP), which summarizes the analysis of final alternatives from the FS and identifies the preferred remedial action alternative

The decision-making process for the cleanup of Operable Unit 1 integrates the requirements of two major environmental laws. The first major law is CERCLA, which establishes the need for this baseline risk assessment and addresses the cleanup of contaminated sites. The second major law, the National Environmental Policy Act (NEPA), requires evaluating the impacts of major federal actions that may significantly affect the quality of human health and the environment. The results of a NEPA evaluation are presented as an Environmental Impact Statement (EIS) or an Environmental Assessment (EA). The documents developed for site cleanup under the RI/FS process of CERCLA are supplemented by an evaluation of NEPA values and therefore also meet the procedural and documentary requirements of NEPA.

The activities and environmental compliance documents for Operable Unit 1 are developed in coordination with EPA Region V and the State of Ohio. The documents are also made available to the public, and public involvement is an important factor in the decision-making process for site remediation. The primary evaluation documents of the RI/FS-NEPA document (i.e., the RI, Baseline Risk Assessment, FS, and PP) will be used to develop the record of decision (ROD) for cleanup of Operable Unit 1. Responses to public comments will be addressed in a responsiveness summary and

incorporated into the ROD, which will be included in the Administrative Record with the final RI/FS-NEPA document package for this action. Following the ROD, remedial design and remedial action activities will be implemented at Operable Unit 1. Public involvement in the proposed action will continue during the post-ROD period.

Environmental compliance activities at the Fernald site are governed by several legal agreements in addition to regulatory requirements. The Ohio Environmental Protection Agency (OEPA) regulates most Resource Conservation and Recovery Act (RCRA) activities while EPA oversees CERCLA activities. Although many CERCLA and RCRA activities overlap in certain situations, there is no tri-party agreement between EPA, OEPA, and DOE that addresses overlapping issues.

E.1.1.2 General FEMP Description

The site is located on 425 hectares (1050 acres) in Hamilton and Butler counties, approximately 17 miles northwest of downtown Cincinnati, Ohio (Figure E.1-1). The main physiographic features in the area are gently rolling uplands, steep hillsides along major streams, and the Great Miami River Valley. The site is generally open grassland, with wooded areas on the southern, western, and northern portions.

Located on relatively flat terrain, the site slopes gently from the northeast to the southwest. Drainage on the site is generally from east to west into Paddy's Run Creek (Paddy's Run), the primary surface drainage feature of the site. An intermittent tributary of the Great Miami River, Paddy's Run flows from north to south near the western boundary of the site (Figure E.1-2). Paddy's Run has historically received direct runoff from the western sections of the site, including the waste storage areas. A small tributary of Paddy's Run, known as the storm sewer outfall ditch, is located to the south and east of the former production area.

Bounded on the west and south sides by roads, the perimeter of the irregularly-shaped site property is fenced, with the exception of two road entrance portals. A second inner fence line surrounds the former production area and waste disposal area (Figure E.1-3). The facility contains several large buildings and several waste ponds and storage silos. The structures contain stored materials and inactive process equipment. A railroad spur runs along the north side of the former production and waste disposal areas.

There are no residences within the Fernald site. Land use in the vicinity of the site is mainly agricultural, with dairy, beef, corn, and soy bean production. Several industries are located south of the facility. The Miami Whitewater Forest, a Hamilton County park, is located within five miles of the Fernald site. Scattered residences and several villages, including Fernald, New Baltimore, Ross, New Haven, and Shandon are located near the site. There is an estimated population of more than 24,000 people within five miles of the site. The nearest residence is within three quarters of a mile

(1200 meters) of the center of the facility. The nearest residences to the western boundary are located along the western side of Paddy's Run Road (Figure E.1-2). A dairy operation, Knollman Farm is located on Willey Road just outside the southeast corner of the site's property boundary. Several residences are located along Paddy's Run Road, approximately one-half mile south of the facility's property boundary, and along New Haven Road, approximately one mile south of the property boundary. There are no schools, daycare centers, hospitals, or nursing homes within a one mile radius of the site. The Site Wide Characterization Report (DOE 1993c) provides more detailed information on local populations, physical features of the area, and land uses surrounding the site.

From 1952 to 1989, the site operated with the primary mission of producing uranium metal products for use as feed materials in DOE and Department of Defense (DOD) programs. Production at the Fernald site peaked in 1960 at approximately 12,000 metric tons of uranium (mtu) per year. A product decline began in 1964, and reached a low in 1975 of about 1230 mtu. During the 1970s, DOE considered closing the Fernald site. However, production levels subsequently increased in the 1980s, and there was a rapid employment increase for several years. Implementation of a major facilities restoration program followed. Production ceased in July 1989; shutdown became permanent in June 1991 when the site mission changed from production to environmental restoration and waste management. The on-property worker population includes employees of DOE, FERMCO, and other contractors.

During its operating life, the site was called the Feed Materials Production Center (FMPC). When the site mission changed, the FMPC changed its name to the Fernald Environmental Management Project (FEMP). The site is referred to throughout this report as the FEMP even though most of the activities described herein took place during the site's production years.

The Fernald facility converted uranium ore concentrates and "recycle materials" into high-purity uranium metal with varying isotopic ratios. Some of this metal was cast into ingots and shipped to the DOE facility located at Reactive Metals, Incorporated (RMI), in Ashtabula, Ohio, for extrusion into bars. These extrusions were returned to Fernald for heat treating and fabrication into target element cores for DOE reactors. Section 1.0 of the RI report includes a more detailed description of the uranium production process at the FEMP facility.

A variety of chemical and metallurgical processes were utilized at the FEMP to manufacture uranium products. Eight separate operation plants associated with the production facility generated a variety of radioactive and nonradioactive wastes. Large quantities of liquid and solid wastes were generated by the various operations. Before Spring 1984, solid and slurried wastes from these processes were disposed in the waste storage area. Between 1984 and 1987, liquids from the general sump were discharged to Pit 5. This area includes six low-level radioactive waste storage pits, the Biondenitrification Surge Lagoon (BSL), the Clearwell, the Burn Pit, two earthen-berm concrete silos

containing K-65 silo residues, one concrete silo containing waste residue, one empty silo, two lime sludge ponds, and a sanitary landfill. Portions of the waste storage area are included in Operable Unit 1, Operable Unit 2, and Operable Unit 4.

The major types of waste streams generated at the site include depleted magnesium fluoride slag, slag leach filter cake, neutralized raffinate, depleted sump cake, general sump sludge, and dust collector residues. Several radionuclides are known to have been present in feed materials processed, stored, or disposed at the FEMP. Uranium, composed of the isotopes U-238, U-234, and U-235, is the most abundant radioactive material within the stored waste. Small quantities of transuranics and fission products — including strontium-90 (Sr-90), cesium-137 (Cs-137), ruthenium-106 (Ru-106), and technetium-99 (Tc-99) — also may be contained in plant effluents and wastes as a consequence of handling some reprocessed metals. Other types of wastes sent to the waste pits include 1,1,1-trichloroethane, spent barium chloride salt, methylene chloride/perchloroethylene degreaser, PCB waste, contaminated waste oil, caustic bases and acids, contaminated and uncontaminated scrap metal, construction debris, and rubble.

In addition to uranium foundry operations, the FEMP processed small amounts of thorium from 1954 to 1975. Since 1975, Fernald has received, assayed, and stored quantities of thorium-bearing materials for potential use in future DOE programs. The site maintains long-term storage facilities for a variety of thorium materials as part of its role as the thorium repository for DOE. Thorium is also found in the waste pits.

E.1.2 OPERABLE UNIT 1 BACKGROUND

The background information presented in the following sections provides a general overview of Operable Unit and its existing contamination. More detailed information describing each of these topics is presented in the RI report.

E.1.2.1 Description of the Waste Pit Area

As shown in Figure E.1-2, the waste pit area is located in the northwest corner of the facility. The specific features of Operable Unit 1 are shown in Figure E.1-4. Waste Pits 1 through 6, located west of the former production area, contain a variety of liquid and solid wastes that were generated by eight separate operations plants at the site. Waste Pits 1 through 4 and the Burn Pit are covered with earth and Waste Pits 5 and 6 are covered with water. The Clearwell was a settling pond, and the Burn Pit contains residue from burned refuse. The following is a brief summary, based on process knowledge, describing each unit located within Operable Unit 1 and types of wastes received. Table E.1-1 provides a detailed listing of wastes disposed in Operable Unit 1. A more detailed description of each of the units in Operable Unit 1 is included in Sections 1.0 and 3.0 of the RI Report.

Waste Pit 1

This waste pit is a Solid Waste Management (SWMU) used primarily for dry, solid wastes between 1952 and 1959. From 1958 to 1959 the waste pit was also used as a settling basin for effluent from Waste Pit 2. Waste material placed in this waste pit consisted primarily of neutralized slag leach filter cakes, depleted sump cakes, depleted MgF_2 slag, scrap graphite, contaminated brick, and sump liquor. The waste in Waste Pit 1 is approximately 18 feet deep.

Waste Pit 2

This unit is a SWMU that operated between 1957 and 1964, and was used primarily for disposing dry, solid wastes. This waste pit was constructed near a small pond east of Waste Pit 1 and was lined with a compacted clay layer. The waste pit received primarily dry, low-level radioactive wastes consisting of neutralized waste filter cakes, sump cakes, depleted MgF_2 slag, contaminated brick, sump liquor, and concentrated raffinate residues. Raffinate residues were placed in Waste Pit 2 between 1958 and 1959, during which time the waste pit functioned as a settling basin. Waste Pit 2 is 23.5 feet deep and contains approximately 24,200 cubic yards (yd^3) of waste. Waste Pit 2 was covered with fill and graded to direct surface drainage to the Clearwell for subsequent discharge to the Great Miami River.

Waste Pit 3

This waste pit also is a SWMU and was built for settling solids from wet waste streams. The waste pit, which operated between 1959 and 1977, was a large settling basin with a concrete spillway that overflowed into the clay-lined Clearwell. This was the first "wet" waste pit built for settling solids from wet waste streams. The waste pit was used to dispose of slag leach residue, filter cakes, flyash, and lime sludges. The principal waste contained in Waste Pit 3 is lime-neutralized radioactive raffinate concentrate. Waste Pit 3 is approximately 42 feet deep and contains an estimated 204,000 yd^3 of waste.

Waste Pit 4

The unit served as a landfill from 1960 until 1986. Waste Pit 4 received process residues, filter cakes, slurries, raffinates, graphite, noncombustible trash, and asbestos. Waste Pit 4 is approximately 32 feet deep and contains an estimated 55,100 yd^3 of waste. The waste contained in Waste Pit 4 is classified as "mixed waste," containing both RCRA hazardous waste and radioactive waste. Waste Pit 4 has undergone an interim RCRA closure, certified by the OEPA. The final closure of Waste Pit 4 is deferred to the CERCLA program. Interim closure activities included covering the waste pit with fill material (soil and rocks), installing a 6-foot compacted clay cap and covering the waste pit with a polyethylene liner.

Waste Pit 5

Waste Pit 5 operated from 1968 to 1983, and is considered as a Hazardous Waste Management Unit (HWMU) under RCRA. The total waste volume of Waste Pit 5 is approximately 97,900 yd^3 and is

approximately 29 feet deep. Until 1983, liquid waste slurries, including neutralized raffinate, neutralized slag leach residue, lime sludge, and sump sludge were pumped to Waste Pit 5 for solids to settle. Between 1983 and February 1987, Waste Pit 5 received only clear decant from the general sump, filtrate from Plant 8, or nonradioactive slurries that flowed across Waste Pit 5 to the Clearwell. Waste Pit 5 is water covered.

Waste Pit 6

Waste Pit 6 was constructed in 1979 and operated until 1985. The unit covers approximately 0.3 hectare (0.75 acre), with a maximum depth of 24 feet. The estimated total volume of waste in Waste Pit 6 is 9,600 yd³. The surface of Waste Pit 6 is presently covered with up to two feet of water to reduce the release of fugitive emissions. Fine-grained solid waste — including green salt, filter cakes, and process residues containing elevated levels of uranium — have been placed in Waste Pit 6.

Clearwell

The Clearwell, which was opened in 1959, was originally used as the final settling basin for the wet chemical waste pits (Waste Pits 3 and 5). The Clearwell now receives only storm water runoff from most of the surfaces of Waste Pit 1, 2, and 3 and from the entire surface of Waste Pit 5. The Clearwell is lined with clay and has a surface area of approximately 2737 square meters (29,461 square feet) and contains approximately 3700 yd³ of waste. Storm water from the waste pit area is now collected and pumped to the BSL as discussed in Section 1.5.4.2 of the RI Report.

Burn Pit

This is another SWMU that was used to dispose of combustible items. The Burn Pit was constructed when clay was excavated from it to line Waste Pits 1 and 2. Beginning in 1957, the Burn Pit was used to dispose of laboratory chemicals and to burn materials, such as uranium metal scraps, pyrophoric and reactive chemicals, oils, and other low-level contaminated materials. Other wastes burned in the waste pit include boxes and wooden pallets, noncombustible items such as laboratory glassware, miscellaneous metal containers (other than drums), and graphite crucibles. The Burn Pit was taken out of service in 1969 and covered with clay. The Burn Pit had an approximate surface area of 2,019 square meters (21,732 square feet) and contains approximately 30,300 yd³ of waste. Although the Burn Pit is located between Waste Pits 3 and 4, the boundaries are no longer discernible.

E.1.2.2 Operable Unit 1 Response Actions

A Baseline Risk Assessment is prepared to address a contaminated site as it exists and should reflect conditions resulting from completed interim actions. The Baseline Risk Assessment does not, however, reflect conditions expected to result from planned actions or actions that have not been fully implemented. Potential health risks associated with future remedial actions at the FEMP will be addressed as part of the remedial alternatives evaluation in the FS of each operable unit. Therefore, the Baseline Risk Assessment for Operable Unit 1 reflects conditions resulting from interim actions

that have been completed as of April 1993, but not conditions that will result from planned or ongoing removal or interim actions.

Removal actions are intended to control or eliminate a release or threat of release of hazardous constituents before a final remedial action if there is a threat to public health and welfare or the environment. At the time this risk assessment was conducted, five removal actions had been completed within Operable Unit 1:

Removal Action No. 2, Operable Unit 1 Study Area Runoff Control

This removal action, completed in July 1992, involved control of radioactively contaminated storm water runoff from Operable Unit 1 as discussed in Section 1.5.4.2 of the RI. Waste storage units within Operable Unit 1 that were included in this removal action were Waste Pits 1 through 6, the Burn Pit, and the Clearwell.

Removal Action No. 6, Control of Exposed Material in Waste Pit 6

This removal action, completed in December 1990, involved redistributing the exposed material so all solids were below the water cover level in Waste Pit 6. This removal action reduced particulate emissions to the environment.

Removal Action No. 11, Waste Pit 5 Experimental Treatment Facility

This removal action involved the dismantling of the Experimental Treatment Facility, removing surrounding soils to prevent any potential spread of contamination beyond the immediate area, and packaging the waste materials generated during this removal action for storage pending final disposition. This action was completed in March 1992.

Removal Action No. 18, Control of Exposed Material in Waste Pit 5

This removal action, completed in December 1992, involved dredging the exposed material below the waterline. The completion of this removal action reduces the threat of airborne particulate radioactive emissions from the exposed material in Waste Pit 5.

Removal Action No. 22, Study Area Contaminant Improvement

This removal action was performed to minimize the potential for wind and water erosion of contaminated materials from access roads and exposed surfaces in OU1. This removal action was completed June 30, 1993.

In addition to these removal actions, Waste Pit 4 has undergone interim RCRA closure, certified by the OEPA. Final closure has been deferred to the CERCLA program. Closure conditions are reflected in the Baseline Risk Assessment for Operable Unit 1.

E.1.2.3 Data Sets used in the Operable Unit 1 Baseline Risk Assessment

Contamination within Operable Unit 1 was evaluated using the results from three sampling and analytical efforts. Each effort was conducted by a different sampling group, but many of the sampling and analysis techniques employed were similar. A detailed discussion of sampling events is provided in Section 2.0 of the RI.

E.1.2.3.1 Weston (CIS)

Roy F. Weston performed a CIS of the FEMP waste storage areas in 1986 and 1987. The waste storage areas include what is now identified as the Operable Unit 1 Study Area. The findings of the CIS were published in three volumes. A geophysical survey, as documented in "Volume 1: Geophysical Survey", was conducted to provide information on waste concentrations and shallow stratigraphy as well as to locate buried steel drums and tanks. Magnetic and electromagnetic terrain conductivity and ground penetrating radar surveys were performed in the waste storage areas including Waste Pits 1, 2, 3, and 4, and the Burn Pit. "Volume 2: Chemical and Radiological Analyses of the Waste Storage Pits" reports the findings of analyses performed on waste pit media, as well as liquid and sediment from those waste pits with standing liquid caps. Chemical analyses performed included RCRA characteristics, EPA HSL inorganics, HSL organics with a library search for non-HSL constituents, indicators, and ions. The scope of radiological testing provided for on-site gamma spectroscopy analysis. Selected samples were then sent off site for radiochemical analysis for uranium, thorium, and several other radionuclides. "Volume 3: Radiological Survey of Surface Soils" describes the radiological characterization of the surface soils throughout the waste storage area and associated drainage routes. Initially, a grid based on 50-foot spacing was set up throughout the study area. Surface soils were systematically surveyed with a Field Instrument for Detecting Low-Energy Radiation (FIDLER) and verified with a Geiger Mueller (GM) detector. A finer grid based on 6.5-foot spacing was used over areas with elevated readings. Soil samples collected down to 18 inches below ground, detected with U-238 activity concentrations greater than 35 pCi/g, were analyzed on site by gamma spectroscopy for various radionuclides. Of the samples analyzed on site, those with the highest activity concentrations were then analyzed off site for uranium, thorium, and other radionuclides.

E.1.2.3.2 RI/FS

Extensive sampling was performed in support of Operable Unit 1 RI/FS efforts. The objectives of the sampling program included: (1) characterize the nature and extent of contamination; (2) determine the associated risk to human health and the environment; and (3) evaluate potential remedial options. During sampling activities from 1987 to 1993, the following media were sampled: waste pit materials and associated leachates from the clay capped waste pits — Waste Pits 1, 2, 3, and 4, and the Burn Pit; surface soils; subsurface soils; surface water and sediment; perched groundwater; and groundwater from the upper, middle, and lower Great Miami Aquifer. All media except the ecological media samples had at least three samples analyzed for full HSL parameters and various radiological

parameters. Testing of ecological samples of benthic microinvertebrates, vegetation, and fauna included HSL inorganics and organics but not pesticides and PCBs. Waste pit media and leachate were also tested for dioxins and furans, 40 CFR 264 Appendix IX parameters, and general chemistry parameters. Additionally, water quality parameter analyses were applied to liquid samples from waste pit media leachate, surface water, and groundwater. Geotechnical testing was performed on waste pit media and sediment.

E.1.2.3.3 RI/FS 1992 Sampling Investigation of Waste Pits 5 and 6, and the Clearwell

In a separate sampling event under the RI/FS program, leachate and sediment from the three water-covered pits — Waste Pits 5 and 6, and the Clearwell — were sampled. These data were originally intended for use for treatability purposes but were also needed to supplement CIS characterization data to establish the source term for each of the waste pits for fate and transport modeling. Samples were obtained with a crane equipped with a clamshell bucket. After excess liquid was decanted from the sediment, the leachate and sediment samples were shipped for analytical testing for those parameters listed in 40 CFR 261 Appendix VIII and 40 CFR 264 Appendix IX.

E.1.2.4 Nature and Extent of Operable Unit 1 Contamination

Environmental media — including waste material, leachate, waste pit water, surface soil, surface water and sediment, subsurface soil, perched groundwater, and biological resources — at the FEMP have been sampled to determine the nature and extent of contamination at Operable Unit 1. This section is a summary of the results of these analyses. A more detailed summary can be found in Section 4.0 of the RI.

E.1.2.4.1 Waste Pits

Both radiological and chemical testing were performed on material taken from the Operable Unit 1 waste pits. The principle radiological contaminants in waste pit materials were determined to be uranium, thorium, and radium isotopes. Other radionuclides such as Tc-99, Sr-90, plutonium isotopes, and neptunium (Np-237), were found in trace amounts. Waste pit materials consistently exceeded background levels by one to six orders of magnitude although the variations do not follow any discernable patterns. Results were not only heterogeneous from waste pit to waste pit and from boring to boring within each waste pit, but also between samples taken from different depths of the same boring. In general, Waste Pits 2 and 4 had noticeably higher levels of radiological contamination than the other waste pits, while the Burn Pit contained the least amount of radiological contaminants.

With respect to chemical constituents within waste pit materials, all borehole samples fell within established limits for RCRA characteristics of corrosivity, reactivity, ignitability, and EP Toxicity. Several Hazardous Substances List (HSL) inorganic analytes existing in the waste materials exceeded background levels by more than one order of magnitude. The principal constituents include arsenic, barium, beryllium, boron, cadmium, chromium, copper, cyanide, lead, manganese, mercury,

molybdenum, nickel, selenium, sodium, and vanadium. Again, distribution trends of these constituents are not discernible.

Leachate samples collected from Waste Pits 4, 5, and 6 and the Clearwell contained uranium and technetium as the principal radionuclides. HSL inorganic results generally reported the presence of the same constituents as reported in the surrounding waste material in each waste pit.

Surface liquids from Waste Pits 4, 5, and 6 and the Clearwell, with standing liquid covers, were also analyzed. Note that Waste Pit 4 was capped after the Characterization Investigation Study (CIS) sampling, but prior to RI/FS sampling efforts. As with the leachates, the principal radionuclides in surface liquids were found to be uranium and technetium. Cyanide, vanadium, and zinc were principle inorganics detected in surface liquids. A few organic compounds were detected in minor concentrations.

E.1.2.4.2 Surface Soils

The results of surface soil radiological analyses indicate that uranium was the predominant radionuclide contaminant in the surface soils of Operable Unit 1. Although U-238 occurred above background concentrations at all sampled locations, no discernable trend was present. Radium-226 and Thorium-232 were also detected above background concentrations in a comparatively limited number of samples, principally in samples taken east of Waste Pits 1, 2, 4, and 5.

Predominant inorganic compounds detected in surface soil chemical analyses were analytes antimony, barium, chromium, lead, manganese, nickel, silver, vanadium, and zinc. Although volatile and semivolatile organic analyses were not performed on surface soils, analyses for pesticides and PCBs did occur. While no pesticides were detected, a limited number of samples contained Aroclor-1254 and Aroclor-1260.

E.1.2.4.3 Subsurface Soils

The subsurface soils surrounding each waste pit were assessed for radiological constituents. Subsurface soils were collected from the glacial overburden, the upper saturated sand and gravel, the lower saturated sand and gravel, and the deep sand and gravel aquifers. The principal radiological constituents in the subsurface soils were identified as isotopic radium, thorium, and uranium. Peak isotopic levels ranged from one to three orders of magnitude greater than background levels with the highest concentrations found in the shallow glacial overburden from zero to three feet in depth. The highest shallow soil concentrations of U-238 were detected in the following areas: between the southern portions of the Burn Pit and Waste Pit 4; north of the Burn Pit, south of Waste Pit 5; east of Waste Pit 4, south of Waste Pit 6, and in the western portions of Waste Pit 5. Two areas with notable concentrations greater than three feet in depth are the area between the Burn Pit and Waste Pit 5 at

0387

4787

approximately 35 feet below grade and between the southern portions of the Clearwell and Waste Pit 1 at a depth of 15 feet.

E.1.2.4.4 Groundwater

All of the 1000-series wells, which are relatively shallow and monitor perched groundwater in the glacial overburden, had detectable levels of uranium isotopes exceeding background activity levels. Notable observations occurred in Well 1021 on the south margin of Waste Pit 4 and in those wells on the northern margin of Waste Pit 4 and northwestern margin of Waste Pit 6. A pattern of elevated detections of U-238 in Operable Unit 1 perched groundwater appears to be centered in the vicinity of the Burn Pit and surrounding most of Waste Pit 4. Thorium and radium isotope activity levels displayed a similar distribution to that of uranium, but were found in lower concentrations. Organic contamination in the 1000-series wells was limited. Well 1031, located east of the Clearwell, had significant contamination.

The 2000-series wells monitor the upper portion of the Great Greater Miami Aquifer. The majority of the radiological contamination, primarily uranium isotopes, present in the 2000-series wells appears to be localized in the east and northeast portion of Operable Unit 1 in the vicinity of Waste Pits 4, 5, and 6, and the Burn Pit. Groundwater at this depth flows west to east, and the wells located west of the four source areas previously mentioned contained significantly lower levels of radionuclides.

Thirteen inorganic constituents were detected in 2000-series well samples. These analytes include aluminum, arsenic, cadmium, chromium, copper, magnesium, manganese, molybdenum, nickel, silver, vanadium, and zinc. Wells 2019, 2027 and 2084, located in the northeast section of Operable Unit 1, consistently showed elevated levels of these constituents. A limited number of organic constituents was detected in the 2000-series wells.

The 3000-series wells monitor a deeper region of the Great Miami Aquifer. Elevated uranium concentrations were detected in every 3000-series well except one, which is located up-gradient to the waste pits. These wells also had 11 inorganic constituents detected above background concentrations and limited detection of organic compounds.

E.1.2.4.5 Surface Water and Sediment

Surface water sampling at 12 locations along drainage pathways indicates that radionuclides are present in the storm water runoff from the Operable Unit 1 Study Area. Likewise, sediment samples revealed widespread uranium contamination in most of the drainage pathways within Operable Unit 1.

E.1.2.4.6 Biological Data

Radiological constituents were detected at low levels in soil, agricultural crops, and garden produce sampled from the off-site control area and other areas in the vicinity of the FEMP. In addition, elevated levels of arsenic, barium, mercury, and zinc were noted.

Mammals caught in the vicinity of Operable Unit 1 were free of detectable concentrations of organics. However, elevated levels of arsenic, fluoride, sulfate, and zinc were recorded. Fish collected in Paddy's Run to the west of Operable Unit 1 yielded no detections of organics or pesticides, although elevated concentrations of aluminum, arsenic, barium, cadmium, fluoride, mercury, sulfide, and zinc were found. A more comprehensive presentation of biological data is presented in the Site Wide Characterization Report (DOE 1993c).

E.1.3 RISK ASSESSMENT GUIDANCE

E.1.3.1 Applicable Guidance

To the extent possible, this assessment follows guidance available from EPA as of July 1993. In accordance with the Amended Consent Agreement between EPA and DOE (1991), a methodology was prepared for performing risk assessments at Fernald. This methodology, presented in the Risk Assessment Work Plan Addendum (DOE 1992a), was prepared to establish specific risk assessment methodology to be followed in all RI/FS risk assessments for the FEMP. The Risk Assessment Work Plan Addendum is based primarily on the following EPA guidance and databases:

- Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Volume I, Part A, Interim Final (EPA 1989a)
- Exposure Factors Handbook (EPA 1990b)
- Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Volume I, Supplemental Guidance, Standard Default Exposure Factors, Interim Final (EPA 1991a)
- Integrated Risk Information System (IRIS) (EPA 1993a), an on-line database of toxicological information
- Health Effects Assessment Summary Tables (HEAST) (EPA 1992b)

Additional EPA guidance, including supplements to the previously mentioned documents, was used and cited where appropriate.

E.1.3.2 Modifications and Enhancements To Risk Assessment Work Plan

The Baseline Risk Assessment is performed in accordance with the Risk Assessment Work Plan Addendum (DOE 1992a) with the following exceptions:

0389

- Constituent concentrations based on measurement data from small sample populations (less than seven samples) are calculated from the arithmetic mean for the log transformed data.

Justification: The type of distribution cannot be confidently determined for data sets with small sample sizes. Normality is assumed for small sample sizes as default because EPA Region V has specifically requested this treatment (EPA 1992c).

- Target organ effects were not determined when evaluating exposure to systemic toxicants.

Justification: Target organ effects and mode of action were not considered separately for systemic toxicants because in the current source term, hazard indices (HI) were low (typically less than 1) with the exception of the off-property user of meat and milk (HI=11). However, for this receptor, the hazard index was composed of 3 toxicants (silver, zinc, and antimony) all of which had a hazard quotient exceeding 1. For the future source term, all receptor had a hazard index exceeding 1 with the exception of the Great Miami River user. The hazard indices for these receptors were also primarily the result of a few toxicants all with individual hazard quotients exceeding 1. Therefore, the concern for consideration of target organ effects and mode of action are not of concern for evaluation of potential systemic toxicity.

- Risks from ingestion of perched groundwater were calculated; however, they were not summed in the totals for the on-property RME resident adult farmer and child.

Justification: Cancer risks and hazard indices were calculated for ingestion of perched groundwater for consideration even though this aquifer would not provide sufficient yield for a potable water source. Therefore, totals for cancer risks and hazard indices for these receptors were based on the Great Miami Aquifer as the probable potable water source.

- Slope factors for radionuclides are taken from HEAST, Annual Fiscal Year 1992 (EPA 1992b).

Justification: Radionuclides are not included in the IRIS database, so the Operable Unit 1 Baseline Risk Assessment uses the most up-to-date HEAST that were available (EPA 1993) at the time that the quantitative assessment was performed.

- Risks to off-property receptors for future exposure scenarios also are presented.

Justification: Off-property residents may be exposed to the site-related contaminants via air and water transport from the site. The Baseline Risk Assessment for this exposure scenario was specifically requested by EPA in the comment resolution for the Site-Wide Characterization Report.

- In response to EPA guidance on Baseline Risk Assessments issued in February 1992 by Deputy Administrator F. H. Habicht (EPA 1992d), an attempt was made to calculate descriptions of individual risk to include the "central tendency" of the risk distribution for a future resident. This average exposure scenario is known as the central tendency (CT) scenario throughout this report.

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Justification: Specific guidance on the implementation and use of the CT scenario is not yet available from EPA's Office of Emergency and Remedial Response, so interim guidance from EPA Region V has been used in constructing this scenario and in presenting the risks to a hypothetical receptor resulting from the calculated average exposures.

- The methods used to calculate exposures from direct exposures to radiation, dermal contact, and inhalation while showering have been changed to reflect EPA guidance that became available after the Risk Assessment Work Plan Addendum was published. These are presented in more detail in the section on the exposure assessment (Section E.3.0).

Justification: DOE and EPA have agreed that the Baseline Risk Assessment will use the most recently recommended and approved methods, models, and parameters.

- The removal processes considered to predict concentrations in food include the effects of leaching in addition to the radioactive and chemical decay presented in the Risk Assessment Work Plan Addendum. This is presented in more detail in the section on the exposure assessment (Section E.3.0 of this appendix).

Justification: During irrigation and aerial deposition, contaminants are added to the soil. Simultaneously, radioactive decay, chemical degradation, and soil leaching deplete these contaminants. The methodology set forth in the Risk Assessment Work Plan Addendum effectively calculates radioactive decay and chemical degradation, but approximates the effect of leaching by calculating plant concentrations after 70 years of deposition/irrigation. This approach is appropriate for most chemical and radionuclides at the site. However, this approach overestimates the concentrations of very mobile contaminants such as Tc-99. An updated methodology, based on work published in National Council on Radiation Protection (NCRP) Report No. 76 (NCRP 1984) and Commentary No. 3 (NCRP 1989) has been adopted to more accurately represent the physical processes at the site.

- Risks and hazard quotients (HQs) are not quantified for chemicals for which toxicity data are not available.

Justification: It is not possible to perform a quantitative risk assessment for chemicals for which toxicity data are not available. The large number of chemicals that are quantitatively assessed is adequate to provide estimates of risk for this operable unit.

Since publication of the Risk Assessment Work Plan Addendum, EPA has provided additional technical guidance concerning methods, models, and parameters that has been incorporated into this Baseline Risk Assessment to the fullest extent possible. Additional guidance documents are referenced where applicable.

E.1.4 OVERVIEW OF OPERABLE UNIT 1 CONCEPTUAL MODEL

Conceptual site models facilitate consistent and comprehensive evaluation of the risks to human health by creating a framework for identifying the paths by which human health may be impacted by

contaminant **4787** Operable Unit 1. The conceptual models depict the relationships between five elements necessary to construct a complete exposure pathway:

- Sources of potential constituents of concern
- Release mechanisms
- Transport pathways
- Exposure mechanisms and exposure routes
- Receptors

Two conceptual site models were developed for Operable Unit 1 to provide the basis for identifying the potential risks to human health. One conceptual site model considers the potential risks to human health from the current configuration of Operable Unit 1 source terms and receptors (current conditions) and the second model considers potential risks from a hypothetical future configuration of Operable Unit 1 source terms and receptors (future conditions). Three land use configurations are also considered: (1) current land use with access controls; (2) current land use without access controls, and (3) future land use without access controls. The conceptual site models do not consider existing contamination in groundwater or any off-site media, which will be addressed in the Operable Unit 5 risk assessment. Only soil, surface water, and waste pit material from within the boundaries of Operable Unit 1 are considered, as are future groundwater, surface water, and sediment contamination that has as its source the media within the Operable Unit 1 boundaries.

The current source term configuration used in this assessment reflects the physical state of the operable unit as it exists today. The current conceptual site model is based on the following assumptions:

- Waste Pits 1, 2, and 3 and the Burn Pit are covered with soil
- Waste Pit 4 is covered with a RCRA cap (polyethylene over 4 feet of compacted clay)
- Waste Pits 5 and 6 and the Clearwell are completely covered with water
- Infiltration through the site is unaltered
- Surface water runoff is collected by the existing drainage system, so neither contaminated water nor sediment leaves the Operable Unit 1 boundaries
- Vegetative covers remains unchanged
- The effects of radiological and chemical decay of the source are assumed to be minimal

The future source term configuration is hypothetical. It is developed from the assumption that the operable unit may be used for residential and agricultural purposes. This land use development

considers both the site's current configuration and the processes that would act on it if all maintenance activities were discontinued. The future conceptual site model is based on the following assumptions:

- Waste Pits 1 and 2 and the Burn Pit are covered with soil (existing caps)
- The polyethylene cap on Waste Pit 4 breaks down and the clay cap is exposed
- Waste Pits 5 and 6 are half covered with water after infiltration or evaporation and pit material is exposed
- The sediment in the Clearwell remains covered with water because of its depth and steep side
- The cover material over Waste Pit 3 settles into the underlying raffinate and the buried wastes in the pit are exposed
- Waste Pits 1 and 2 are irrigated and used to grow crops and animal feed
- Infiltration through the site is altered by changes in the water levels of the waste pits, the degraded cover of Waste Pit 3, and the use of irrigation on Waste Pits 1 and 2
- Excess surface water runoff flows to Paddy's Run
- Vegetative cover is consistent with local agricultural practices and ecological succession
- A house is placed on the most stable pit (Waste Pit 4) and a well is drilled at the location producing the maximum risk

The future conceptual site model is discussed in greater detail in Section E.3.0.

E.1.4.1 Temporal Considerations/Source Term Scenarios

The Operable Unit 1 Baseline Risk Assessment addresses the effects of time when determining the nature and magnitude of potential human exposures to site contaminants. Over time, dynamic processes in the environment affect chemical mobility and behavior, as well as the bioavailability of contaminants to human receptors. To account for potential changes in exposure concentrations with time, the Operable Unit 1 Baseline Risk Assessment estimates exposure concentrations under both current and future source-term configurations. Over time, contaminant levels in environmental media on- and off-property will change as a result of chemical transport within and between various environmental media, and processes such as chemical partitioning, dilution, attenuation, and degradation. Physical conditions of the property are also assumed to degrade, leaving exposed waste. This hypothetical future source term configuration provides the basis for the analysis of future conditions. The assessment of current conditions addresses only existing levels of constituents of concern in the environmental media of Operable Unit 1, considering the current configuration of the source term. Current concentrations of contaminants are assumed to result from environmental processes operating on the property as it is today.

4787

The various exposure scenarios evaluated for the current and future source terms are described in detail in Section E.3.0 of this Baseline Risk Assessment.

E.1.4.2 Populations of Concern

The exposure assessment presented in Section E.3.0 describes the potential receptors and locations that are selected to assess current and potential future impacts on human receptors on and off site. The potential receptors and receptor locations are determined from a reasonable area of impact considering site-specific environmental conditions; the results of site characterization, environmental monitoring, and contaminant fate and transport modeling, and the nature of potential exposure pathways. Potentially exposed human populations are identified for each distinct land use condition including current and future land use and site access considerations. Subpopulations, such as young children, that could be exposed to increased risk as a result of behavior or increased sensitivity also are identified to address all significant potential relevant human exposure scenarios.

Potential receptors are further characterized according to the degree of potential exposures. In accordance with EPA guidance, risk estimates for receptor populations are developed on the basis of reasonable maximum exposure (RME) conditions. RME conditions can reasonably be expected to occur under current and future land use scenarios, and are defined by conservative exposure parameters. The RME is intended to represent a conservative exposure case that is above the average estimated exposure level. The Operable Unit 1 Baseline Risk Assessment is based on RME assumptions for each potential receptor exposure scenario evaluated.

The Baseline Risk Assessment also evaluates more typical exposure conditions by utilizing a central tendency analysis for a selected receptor. Both central tendency and RME exposure assumptions were used to estimate risks for the on-property resident adult under future land use conditions, thereby providing a range of estimated risks for this important receptor.

E.1.4.3 Land Use Scenarios

The Operable Unit 1 Baseline Risk Assessment addresses a wide range of potential exposure scenarios under a variety of assumptions regarding land use and site access. Currently, land use adjacent to the site is primarily agricultural, with dairy, beef, corn, and soy bean production. In addition, more than 400 acres of open land at the site are being leased to a local dairy farm for livestock grazing. Consistent with these uses, the Operable Unit 1 Baseline Risk Assessment for the current land use scenario addresses receptors both on and off site, including visitors, trespassers, off-property farmers, and on-property cattle grazing.

Long-term risks to the public may be associated with the presence of hazardous substances remaining on the property in the future. These long-term risks are evaluated under the baseline (no-action) assessment, assuming that future land uses will not differ substantially from current uses of the

surrounding area and that site access and use will be unrestricted. Receptors evaluated under future land uses for Operable Unit 1 include the off-property farmer, user of meat and milk, on-property resident, home builder, and a user of Great Miami River.

In addition to land use, the presence of site access controls is also a critical factor in defining potential exposures to on-site contamination. At present, a security fence surrounds the entire site property, and a second line of fences surrounds several internal areas, including the former production area and the waste disposal area. Access in and out of the facility is controlled at security checkpoints, and the fenceline is regularly patrolled. These active (security patrols) and passive (fences) access restrictions have proven to be effective for restricting unauthorized site access and are expected to continue for the foreseeable future. The Baseline Risk Assessment under the current land use assumption includes exposure scenarios that assume that these access controls will remain in effect. However, the Amended Consent Agreement also requires that the Baseline Risk Assessment for each operable unit estimate risks under scenarios that discount the effects of access controls. Therefore, the Baseline Risk Assessment under current land use conditions for Operable Unit 1 also includes risk estimates for a hypothetical scenario assuming that environmental restoration of the property has ceased and present access restrictions are discontinued. This evaluation considers only the current, unimproved condition of Operable Unit 1. The assessment of potential risks under future land use scenarios assumes unrestricted access to the site.

E.1.4.4 Exposure Pathways

An exposure pathway is a route by which a contaminant can move from a source to a receptor. The exposure assessment presented in Section E.3.0 lists the exposure pathways considered during the course of this Baseline Risk Assessment. Exposure pathways were considered if there were (1) a source or chemical release from a source; (2) an exposure point where contact can occur; and (3) an exposure route by which contaminants are taken into the body.

TABLE E.1-1
OPERABLE UNIT 1 UNIT DESCRIPTION

Unit	Period of Operation	Physical Inventory	Physical Description
Waste Pit No. 1 Waste Capacity: 37,000 cubic meters (48,500 cubic yards)	1952-1959	Brick, magnesium fluoride slag, neutralized waste filter cake, scrap graphite, sump cakes from the production facility, sump liquor, uranium	Clay liner; silts and clays with varying grain size; solid, semisolid and grease-like materials
Waste Pit No. 2 Waste Capacity: 18,500 cubic meters (24,200 cubic yards)	1957-1964	Brick, magnesium fluoride slag, neutralized waste filter cake, scrap graphite, sump cakes from production plants, sump liquor, raffinates, thorium, uranium	Clay liner; coarse sand; clay and silt-material of semisolid consistency; fragments of concrete up to 1" in size
Waste Pit No. 3 Waste Capacity: 156,000 cubic meters (204,100 cubic yards)	1959-1977	Liquid effluent and slurries, lime neutralized raffinates, slag leach residues, uranium, thorium	Clay liner; coarse-grained material underlain by very soft, moist to wet, semisolid material; wood fragments
Waste Pit No. 4 Waste Capacity: 42,100 cubic meters (55,100 cubic yards)	1960-1986	Asbestos and paint, dust collector residues, process residues, trailer cake, uranium, thorium, neutralized raffinate, uranium tetrafluoride, uranium trioxide, black oxide, graphite, concrete, flyash, pallets	Clay liner; silt and sand with layers of clay below 10 feet; material was saturated below 9 feet
Waste Pit 5 Waste Capacity: 74,800 cubic meters (97,900 cubic yards)	1968-1987	Neutralized raffinate, neutralized slag leach residue, sump sludge, wastewater from production area (through GS), steel and concrete rubble, uranium, and thorium	Synthetic liner; standing water; 4 feet of watery material with sand-sized grains underlain by 25 feet of a 1,1,1-trichloroethane wet semisolid material with very little cohesion
Waste Pit No. 6 Waste Capacity: 7,340 cubic meters (9,600 cubic yards)	1979-1985	Asbestos, filter cake, process residues containing elevated levels of uranium, UF ₆ , MgF ₂	Synthetic liner; saturated, soft, coarse to fine sand and clay materials
Clearwell Waste Capacity: 2,800 cubic meters (3,700 cubic yards)	1959-present	Arsenic, barium, mercury, aluminum, magnesium, calcium, cobalt, cyanide, calcium fluoride, iron, vanadium, PCBs, trichloroethane	Clay liner; Silt-sized, semisolid material and sand

E-1-22

0396

TABLE E.1-1
(Continued)

4282

Unit	Period of Operation	Physical Inventory	Physical Description
Burn Pit Waste Capacity: 23,200 cubic meters (30,300 cubic yards)	1957-1969	Arsenic, mercury, aluminum, magnesium, calcium, iron, lead, silver, PCBs, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, pentachlorophenol(2), phenanthrene, 2-methylnaphthalene, tetrachlorethane, ethylbenzene, fluoranthene, phenol, xylenes, pyrene;	Silt-sized, semisolid material; sand-sized material; and fill with glass, wood, and aluminum
Experimental Treatment Facility	1984	Same as Waste Pit No. 5 material	Under Closure

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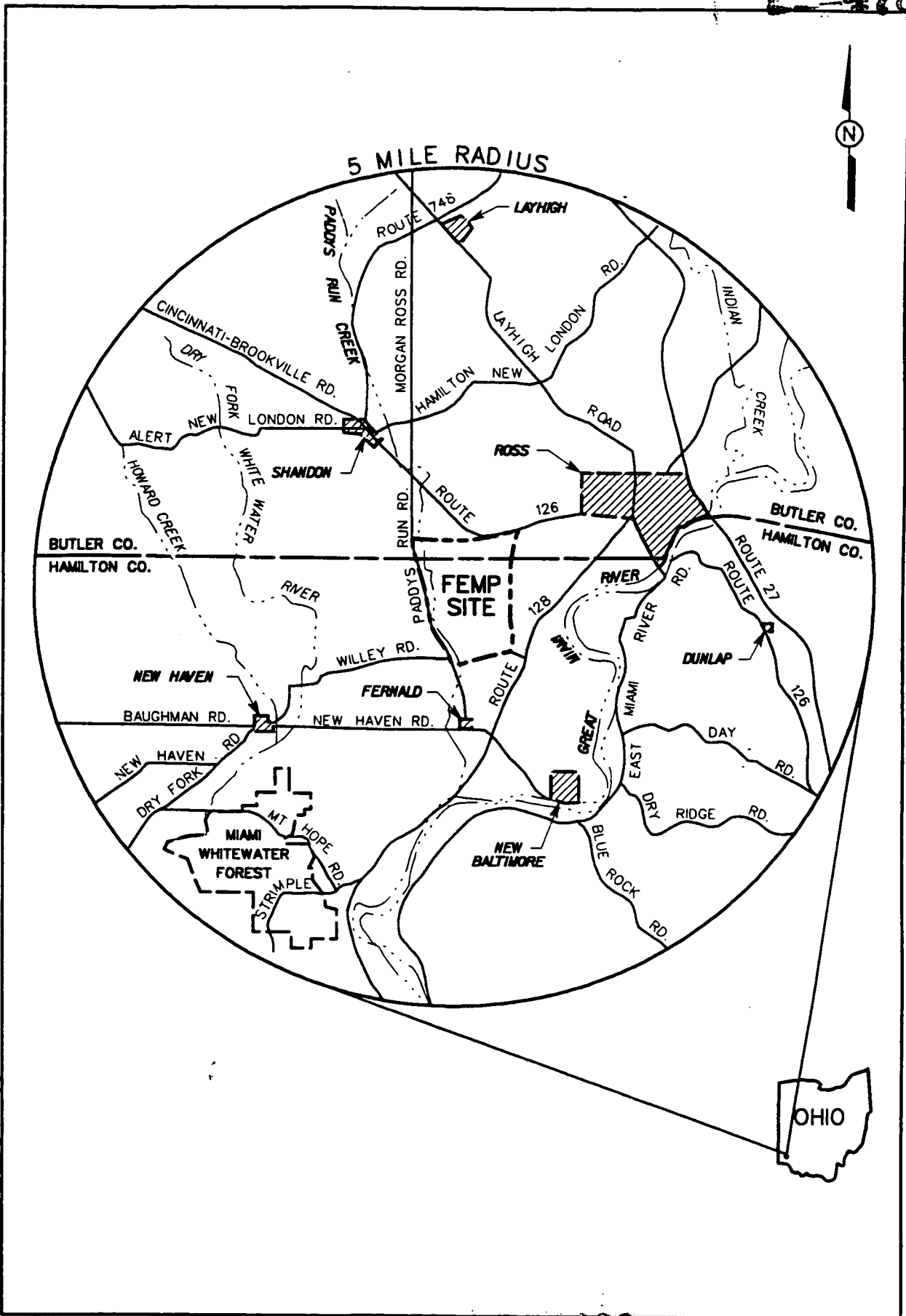


FIGURE E.1-1. FEMP SITE LOCATION MAP

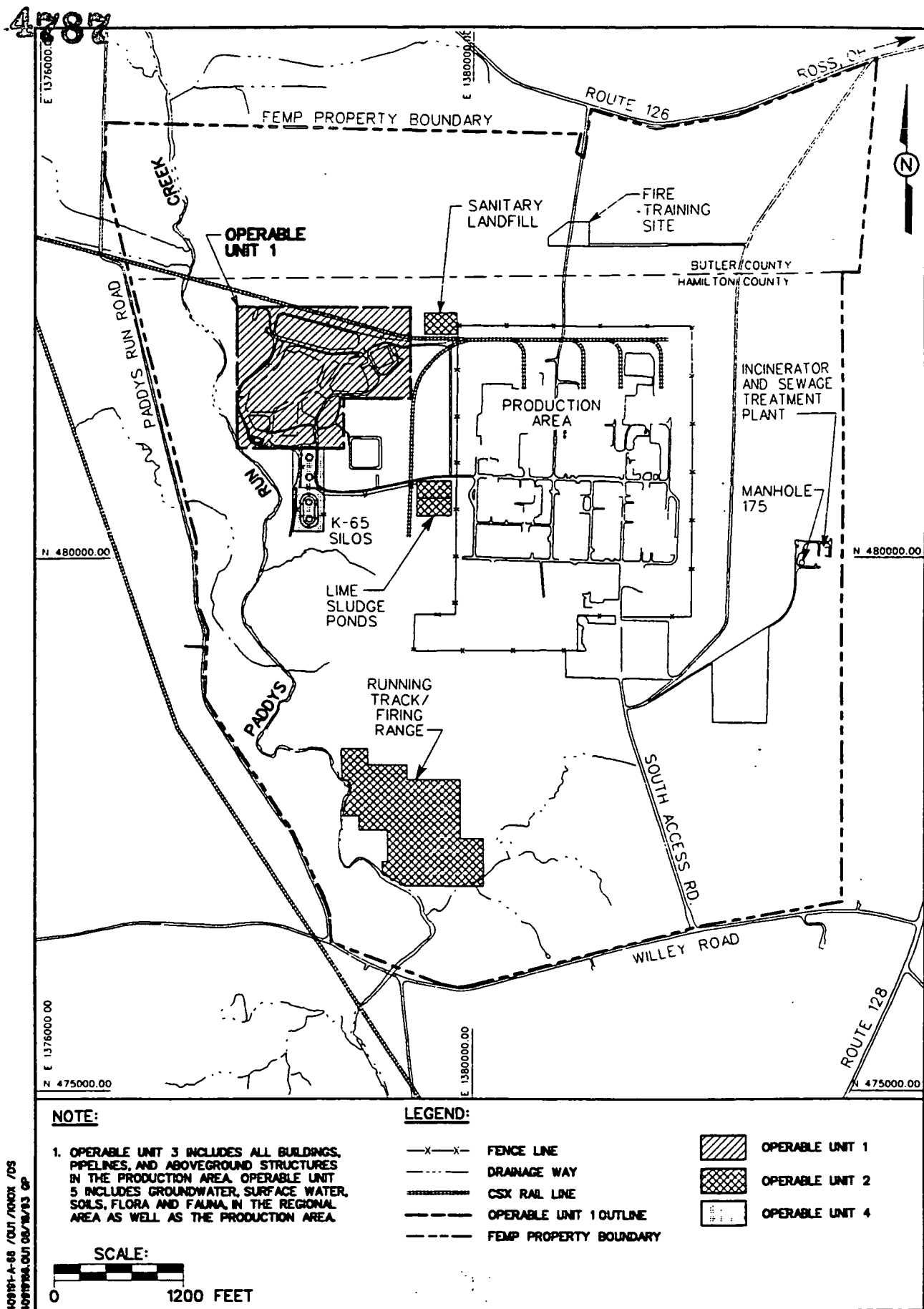
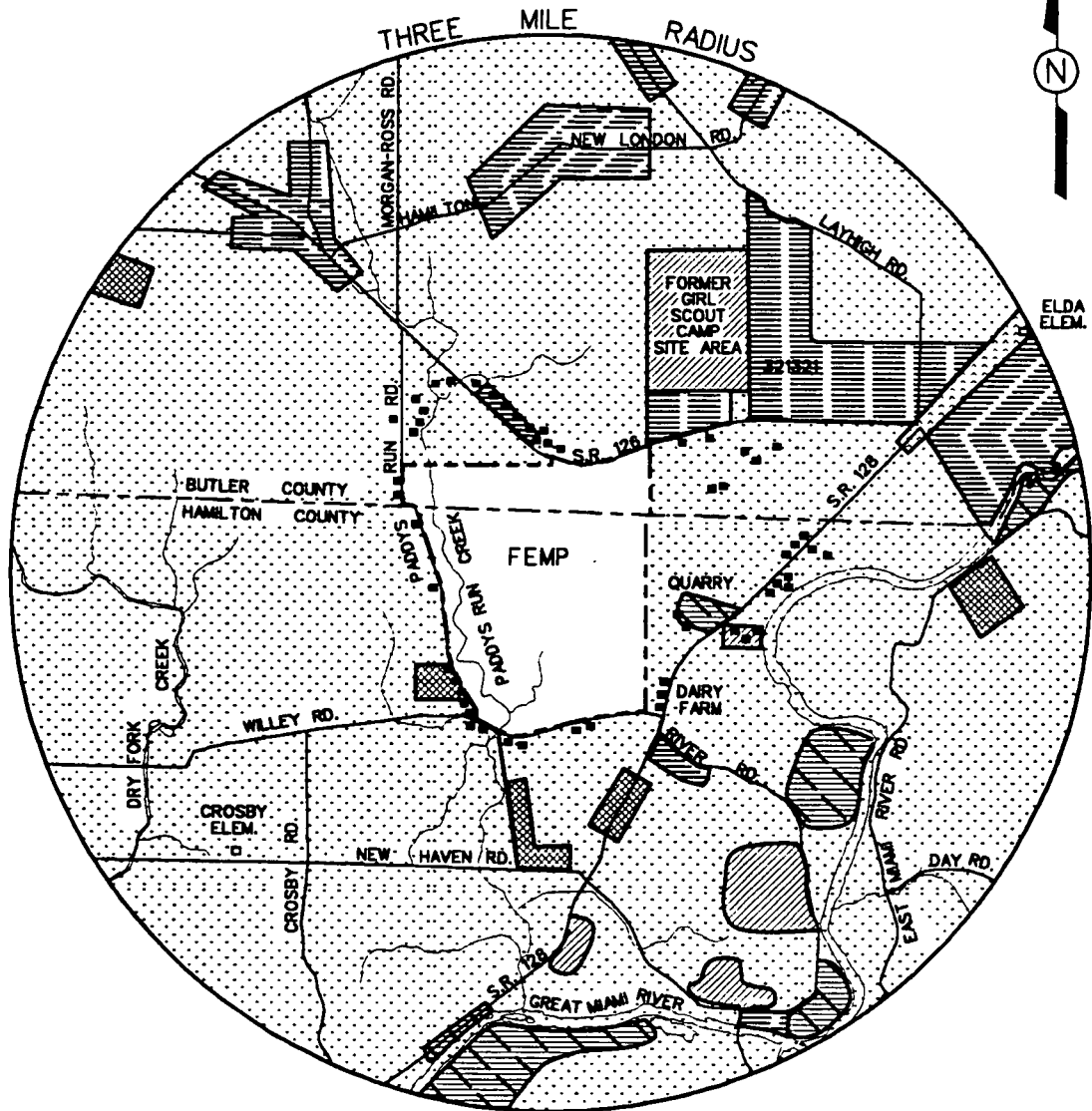


FIGURE E.1-2. LOCATION OF OPERABLE UNIT 1 WITHIN THE FEMP

4787



LEGEND:

- | | |
|---|---|
| --- COUNTY LINE | ■ HOUSES AND BARNES |
| --- FEMP PROPERTY BOUNDARY | □ SCHOOLS |
| [Pattern: Horizontal lines] RESIDENTIAL | [Pattern: Diagonal lines] MINING |
| [Pattern: Stippled] INDUSTRIAL | [Pattern: Dotted] MIXED USE |
| [Pattern: Diagonal lines] RECREATION | [Pattern: Stippled] AGRICULTURE/OPEN LAND |

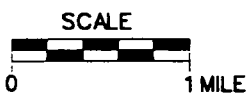
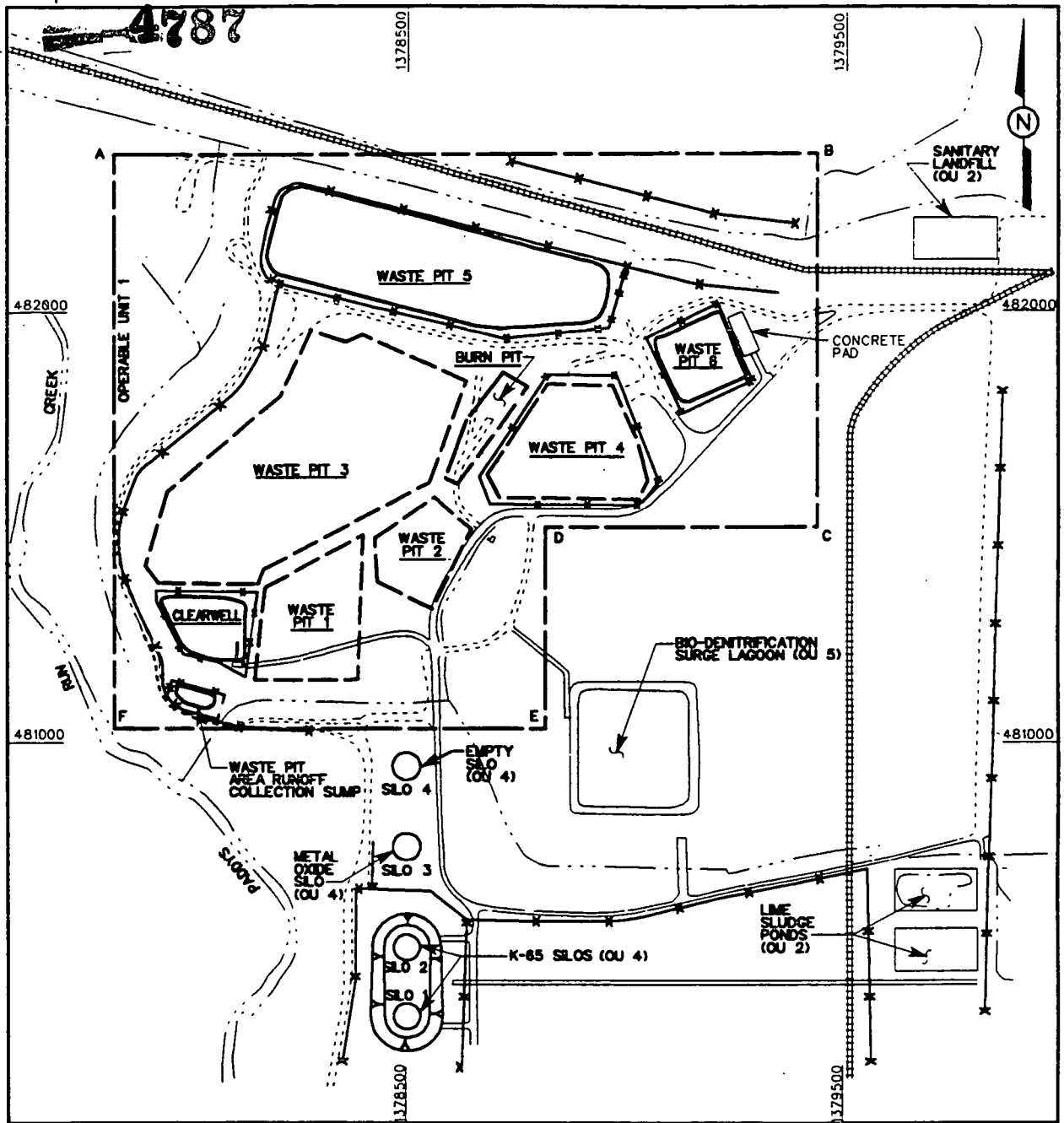


FIGURE E.1-3. LAND USE ADJACENT TO THE FEMP

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NOTES:

1. PITS 1, 2, 3 AND THE BURN PIT ARE COVERED WITH SOIL CAPS AND VEGETATED.
2. PIT 4 HAS AN INTERIM CAP.
3. PITS 5, 6 AND CLEARWELL ARE WATER COVERED
4. COORDINATES SHOWN ARE OHIO STATE PLANAR COORDINATES, ADJUSTED PER THE NORTH AMERICAN DATUM (NAD) OF 1983.
5. OPERABLE UNITS (OU) ARE IDENTIFIED. OU 5 INCLUDES GROUNDWATER, SURFACE WATER, SOILS, FLORA & FAUNA IN THE AREA OTHERWISE IDENTIFIED.

OHIO STATE PLANAR COORDINATES		
POINT	NORTHING	EASTING
A	482364	1377824
B	482364	1378432
C	481499	1378432
D	481499	1378812
E	481033	1378812
F	481033	1377824

LEGEND:

- X — X — FENCE LINE
- - - - - DRAINAGE WAY
- ==== CSX RAIL LINE
- ===== PAVED ROADWAY
- . - . - . GRAVEL ROADWAY
- - - - - OPERABLE UNIT 1 OUTLINE
- - - - - COVERED PIT OUTLINE
- OPEN PIT OUTLINE

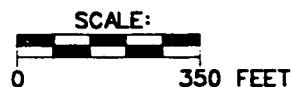


FIGURE E.1-4. OPERABLE UNIT 1 SITE MAP

E.2.0 IDENTIFICATION OF CONSTITUENTS OF POTENTIAL CONCERN

The previously described analytical sampling procedures yielded a large amount of information about the chemicals and radionuclides present in Operable Unit 1. The risk assessment process would be unmanageable without methods to summarize data and determine which constituents pose a potential health threat. This section describes the data used for risk assessment, how the data were evaluated, and how constituents of potential concern (CPCs) were determined. Section E.2.1, Data Sources, describes the database used for risk assessment. Section E.2.2, Data Analysis, describes the data validation procedure. Section E.2.3, Identification of CPCs, describes the methods used to determine which chemicals were important for risk assessment and the results of the CPC determination process for Operable Unit 1.

E.2.1 DATA SOURCES

Investigations producing data acceptable for risk assessment are summarized in Table E.2-1. It is important to note that there are two investigative efforts for each source: the CIS and the RI/FS. A summary of these studies is presented in Section E.1.2.4 of this appendix. A detailed description of these investigations and figures showing sample locations are presented in Section 2.0 of the RI.

In order to determine the relative magnitude that each waste source contributed to the total health risk, and because of heterogeneity between the different sources, Operable Unit 1 data were separated into discrete analytical units. These analytical units are:

- Waste Pit 1
- Waste Pit 2
- Waste Pit 3
- Waste Pit 4
- Waste Pit 5
- Waste Pit 6
- Burn Pit
- Clearwell
- Surface soil between the pits

Data on background concentrations are also compared to on-site results for inorganic and radiological constituents. Data sources for each analytical unit within Operable Unit 1 and the background data are described in the following sections.

E.2.1.1 Waste Pit 1 Contents Data Sources

Material in Waste Pit 1 was sampled during two investigations and sent to an off-site laboratory for analysis. The RI/FS program collected 6 samples for radiological analysis, 6 samples for analysis of HSL inorganic chemicals, and 11 samples for HSL organic chemical analysis. These samples were generally taken from the bottom two-thirds of the waste pit.

The CIS program collected 5 samples for radiological analysis and 10 samples for analysis of inorganic and organic HSL chemicals. These samples were generally taken from the upper two-thirds of the waste pit.

E.2.1.2 Waste Pit 2 Contents Data Sources

The RI/FS program for Waste Pit 2 collected 4 samples and sent them to an off-site laboratory for radiological analysis. In addition, 4 samples were collected for analysis of HSL inorganic chemicals and 9 samples were collected for analysis of HSL organic chemicals. These samples were generally taken from the bottom two-thirds of the waste pits.

The CIS program collected 5 samples and sent them off site for radiological analysis, and 5 samples for analysis of inorganic and organic HSL chemicals. These samples were generally taken from the upper two-thirds of the waste pit.

E.2.1.3 Waste Pit 3 Contents Data Sources

The RI/FS program for Waste Pit 3 collected 6 samples for radiological analysis. Six samples were also collected for analysis of inorganic HSL chemicals and 12 samples were collected for analysis of organic HSL chemicals. These samples were generally taken from the bottom two-thirds of the waste pit.

Seven samples were collected during the CIS for radiological analyses by an off-site laboratory. Six samples were also analyzed for inorganic and organic HSL chemicals. These samples were generally taken from the upper two-thirds of the waste pit.

E.2.1.4 Waste Pit 4 Contents Data Sources

Two investigations were conducted on the material in Waste Pit 4. The RI/FS program collected 5 samples and sent them to an off site laboratory for radiological analysis. Five samples were collected for analysis of inorganic HSL chemicals, while 12 samples were collected for analysis of organic HSL chemicals. The RI/FS samples were generally taken from the bottom two-thirds of the waste pit.

Four samples were collected during the CIS program and were sent off site for radiological analysis. Four samples were also collected for analysis of inorganic and organic chemicals on the HSL. These samples were generally taken from the upper two-thirds of the waste pit.

E.2.1.5 Waste Pit 5 Contents Data Sources

Two investigations sampled material in Waste Pit 5. Analyses were performed by off-site laboratories. The RI/FS waste pit sampling program conducted in 1992 collected 10 samples for radiological

analysis, 10 samples for analysis of inorganic HSL chemicals, and 12 samples for analysis of organic chemicals on the HSL. These samples were grab samples from the upper layers of submerged sludge at the bottom of the waste pit.

The CIS program collected 7 samples for radiological analysis, and 6 samples for analysis of inorganic and organic HSL chemicals. Some of these samples were taken from the upper portions of the exposed waste in the waste pit and other samples were grab samples from the upper layers of the submerged sludge at the bottom of the waste pit.

Two surface water samples were also collected during the CIS. These samples were analyzed for radiological constituents, as well as HSL organics and inorganics.

E.2.1.6 Waste Pit 6 Contents Data Sources

Two investigations sampled material in Waste Pit 6. All analyses were performed by an off-site laboratory. The RI/FS waste pit sampling program conducted in 1992 collected 8 samples for radiological analysis. Twelve samples were collected for analysis of inorganic and organic HSL chemicals. These samples were grab samples from the upper layers of submerged sludge at the bottom of the waste pit.

The CIS program collected four samples for radiological analysis, and 6 samples for analysis of inorganic and organic chemicals on the HSL. Some of these samples were taken from the upper portions of the exposed waste in the waste pit. Other samples were grab samples from the upper layers of the submerged sludge at the bottom of the waste pit.

Five surface water samples were also collected during the CIS and analyzed for radiological and HSL (organic and inorganic) constituents.

E.2.1.7 Burn Pit Contents Data Sources

The RI/FS program at the Burn Pit collected 3 samples and sent them to an off-site laboratory for radiological analysis. Three samples were collected for analyses of inorganic chemicals on the HSL, while five were collected for analysis of organic chemicals on the HSL. These samples were generally taken from the bottom two-thirds of the waste pit.

The CIS program collected six samples and sent them off site for radiological analyses. Six samples were also collected for analysis of inorganic and organic chemicals on the HSL. These samples were generally taken from the upper two-thirds of the waste pit.

4787

E.2.1.8 Clearwell Contents Data Sources

Two investigations sampled material in the Clearwell. The RI/FS waste pit sampling program conducted in 1992 collected six samples and sent them to an off-site lab for radiological analyses. Six samples were also collected for analysis of inorganic and organic chemicals on the HSL. These samples were grab samples from the upper layers of submerged sludge at the bottom of the waste pit.

The CIS program collected four samples and sent them off site for radiological analyses. Three samples were also collected for analysis of inorganic and chemicals on the HSL. Some of these samples were taken from the upper portions of the exposed waste in the waste pit. Other samples were grab samples from the upper layers of the submerged sludge at the bottom of the waste pit.

During the CIS, two surface water samples were collected from the Clearwell. These samples were analyzed for both radiological constituents as well as HSL organics and inorganics.

E.2.1.9 Surface Soil Data Sources

During the RI/FS sampling program, 9 surface soil samples were collected and analyzed for radionuclides. Seventeen surface soil samples were collected and analyzed for inorganic and organic chemicals on the HSL. The location of these samples are depicted on figures provided in Section 2.0.

The CIS sampling program collected 60 surface soil samples within the Operable Unit 1 boundaries and sent them to an on-site laboratory for radiological analysis by gamma spectroscopy. The list of analytes included U-238, Ra-226, Th-232, Ru-106, Cs-137, and Sr-90.

E.2.1.10 Background Sources

Attachment E.I of this Appendix presents a summary of background data for various environmental media. These data were extracted from two sources.

In the spring of 1992, 89 background soil samples were collected at 30 locations in accordance with the "RCRA/CERCLA Background Soil Characterization Study" (DOE 1993a). These samples were analyzed for 17 radionuclides and 27 nonradioactive metals, and the results were evaluated and validated. This report was the primary source on background conditions in the soil.

During the past five years, the environmental monitoring programs at the FEMP have collected data on the background concentrations of a variety of constituents in groundwater and surface water. The data from these programs has been assembled and presented in "Characterization of Background Water Quality for Streams and Groundwater" (DOE 1993). This report was the primary source on background conditions in groundwater and surface water near the FEMP.

0405

4787

E.2.2 DATA ANALYSIS

This section describes how data were analyzed prior to determination of CPCs for each analytical unit. First, the data validation process is discussed. Then the method yielding the final concentration term for each constituent in each of the waste sources is described. These final concentration terms will be used for risk assessment, CPC determination, and fate and transport modeling described in Section 5.0 of the RI.

E.2.2.1 Data Validation

Specific parameters associated with the data were reviewed to determine whether they met the stipulated data quality objectives. The quality objectives addressed five principal parameters: precision, accuracy, completeness, comparability, and representativeness. To verify that these objectives were met, field measurements, sampling and handling procedures, laboratory analysis and reporting, and nonconformances and discrepancies in the data were examined to determine compliance with appropriate and applicable procedures. The procedures and criteria for validation are defined in the RI/FS Data Validation Program Guidelines, which are based on the EPA National Functional Guidelines for Data Review (EPA 1988a, EPA 1988b, EPA 1991f, EPA 1991g, and EPA 1991h).

The validation process for the FEMP RI/FS was divided into two phases. The first phase evaluated field data to verify the completeness and accuracy and representativeness of field sampling. The key field data reviewed in the validation process were:

- Field Activity Daily Logs
- Sample Collection Logs
- Specific field forms for sample collection and handling
- Chain of Custody, Request for Analysis
- Field instrument calibrations
- Field personnel training
- Variances and surveillances of field activities

The second phase dealt with analytical chemical and radiological validation. The key analytical data reviewed in the validation process were:

Organic chemicals

- Holding times
- Gas Chromatography/Mass Spectroscopy (GC/MS) tune
- Initial and continuing GC/MS calibration
- Surrogate recoveries
- Matrix spike, matrix spike duplicates
- Blank evaluation using the 5X/10X rule
- Internal standards

<u>Inorganic chemicals</u>	1
• Holding times	2
• Inductively Coupled Plasma/Graphite Furnace Atomic Analysis instrument performance checks	3
• Initial and continuing calibrations	4
• Blank evaluations	5
<u>Radionuclides</u>	6
• Shipping reports	7
• Holding times	8
• Duplicate precision	9
• Laboratory control samples	10
• Blanks	11
• Detection limits	12
• Matrix spikes	13
• Uranium isotopic ratios	14

The culmination of the validation process was the assignment of the qualifier flag for each analytical result, reflecting the level of confidence assigned to that datum. All of the measured contaminant concentration data obtained in the RI/FS sampling program for Operable Unit 1 have been validated and have been through a peer review process. Data which did not adequately meet the criteria addressed during data validation were flagged with an "R" qualifier. These data were not used in the quantitative baseline risk assessment process according to EPA guidance (EPA 1989a). Section 2.13 of the Operable Unit 1 RI report provides additional information on data qualifiers.

E.2.2.2 Concentration Term

The statistical method used to determine a representative concentration for each constituent is discussed in this section. The rationale used to develop this methodology and the statistical techniques are based on the following sources:

• "Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Volume I, Part A, Interim Final" (EPA 1989a)	27
• "Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 1 and Volume 3 (Draft)" (EPA 1989c, 1990a)	28
• "Statistical Methods for Environmental Pollution Monitoring" (Gilbert 1987)	29
• "Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance" (EPA 1989d)	30
• EPA comments (December 1991 and March 1992) on the statistical methods used in the October 1991 Draft "Risk Assessment Work Plan Addendum" (Saric 1991 and 1992).	31

3044
0407

As mentioned previously, two of the generations of characterization studies were fully validatable for risk assessment purposes: the RI/FS and the CIS data sets. The RI/FS database consisted of results from both the 1991 RI/FS Treatability Study conducted by ASI and the 1992 RI/FS Supplemental Study, consisting of inorganic and radiological analysis of Waste Pits 5, 6, and the Clearwell as performed by WEMCO. This merged data set will be referred to as the RI/FS data set for the purposes of this discussion. The merged RI/FS data set and the CIS data set are analyzed separately, and both were considered when determining the final representative concentration for a constituent.

E.2.2.2.1 Determination of UCL/Max for Each Data Set

Analysis is performed on both data sets before combination. Most sample sizes are too small to assess the distribution of site data, so a normal distribution was assumed. If the analyte is detected within the sample population at least four times, the upper 95 percent confidence limit of the mean concentration (UCL) is calculated using one-half of the sample quantitation limit (SQL) to represent any nondetects.

Calculation of the UCL was performed using Paradox[®] by Borland. Because all sample populations are either closest to normally distributed or assumed to be normally distributed because of small sample size, the following formula is used:

$$UCL = \bar{X} + t_{1 - \frac{\alpha}{2}, n-1}(s/\sqrt{n}) \quad (D.2-2)$$

where

\bar{X}	= arithmetic average value for the sample set
t	= two-sided t distribution factor, based on n-1 degrees of freedom
s	= standard deviation
n	= number of samples

For each data set, a data set concentration term (UCL/Max) is determined by selecting the smaller of the UCL and the maximum detected value (MDV). If a constituent is not detected in the sample population at least four times, the maximum detected value is used as the UCL/Max. If a constituent is not detected within a data set, it is eliminated from further statistical analysis.

E.2.2.2.2 Determination of Final Concentration Term

The final concentration term is determined by selecting the larger of the UCL/Max values from the two data sets. The final concentration term was used for modeling, risk assessment, and CPC screening.

E.2.3 IDENTIFICATION OF CONSTITUENTS OF POTENTIAL CONCERN (CPCS)

CPCs are selected based on the likelihood that they are anthropogenic, site-related, and their ability to produce carcinogenic or toxic effects. This section presents the systematic selection process used to compare constituent concentrations to background levels, and to assess the effectiveness of the constituent in inducing adverse health effects.

E.2.3.1 Methodology

CPCs are determined using a two step procedure. The first is comparison to background levels (applicable to inorganic and radionuclide constituents only). Then, toxicological screening is performed. These steps are described separately below.

E.2.3.1.1 Comparison to Background

Measured on-property concentrations of each inorganic radionuclide are examined to determine if the constituent reflects natural background levels in native soil. The general approach taken is to compare the population of measured concentrations of a constituent in a discrete data set to a population of background concentrations in the same medium. For example, lead in the first six inches of Operable Unit 1 surface soil is compared to lead levels in the first six inches of soil taken at selected background sampling stations to determine if the lead levels detected in soil exceed background.

Statistical procedures are employed to compare the concentrations of CPCs for various media associated with each waste pit. In most cases, the small sample population for each constituent in each analytical unit makes proper assessment of data distribution impossible. Therefore, the use of Student's t-Test is not systematically employed. The Mann-Whitney U Test is used to compare site-related data with background data to determine if the two data sets are from different distributions. The Mann-Whitney procedure ranks the concentrations in the two subject data sets by their magnitudes. The theory behind the distribution independent Mann-Whitney procedure is that if the two data sets are from the same distribution (i.e., the site data is the same as background), then the ranked concentrations would be evenly distributed between the sets. If the ranked concentrations of the two data sets are not evenly distributed, the two data sets may be from two different distributions (and are therefore not comparable).

SYSTAT PC[®]-based software is employed to calculate the probabilities that any observed difference in the data ranking may be attributable to random chance. The Mann-Whitney U statistic is directly correlated to the Wilcoxon Rank Sum procedure yielding identical probability values. A small probability indicates there is sufficient evidence to conclude that the site-related and background data sets are not drawn from the same population. A probability level of 5 percent is employed as a decision point. Constituents with marginal probability levels (5 percent - 20 percent) are subject to further review by statisticians and risk assessment scientists.

4787

E.2.3.1.2 Toxicological Screening

Toxicological screening of CPCs was performed to quickly exclude constituents that would not affect human health risk. The following process was used:

- Contaminant concentration source terms, frequency of detection, persistence, and distribution among media were evaluated. If a contaminant was identified in one medium but not found in any other media or was found at unusually high (unrealistic) concentrations, elimination was considered unless additional evaluation requires it be included as a CPC.
- Essential micronutrients and macronutrients that were non-toxic at the levels identified (e.g., Na, K, Mg, Ca, Fe, Zn, Mg, Se, etc.) were deleted.
- Nonspecific classes of chemical compounds (e.g., total organic carbon, [TOC], total petroleum hydrocarbons [TPH], polynuclear aromatic hydrocarbons [PAHs], chlorinated hydrocarbons [CHs], etc.) were removed.
- Compounds known to be derived from off-site sources (e.g., off-site factory discharges, auto exhausts, various herbicides, insecticides, etc.) were deleted unless their contribution to site risk is significant (e.g., 2, 3, 7, 8-TCDD).
- Compounds that were ubiquitous in nature and considered to be nontoxic (e.g., Al, Si, Cl) were removed. Concentrations of inorganics were compared with background levels to determine whether they were present on site at elevated concentrations.
- Volatile compounds with vapor pressures less than 10 mm Hg at 20 degrees Celsius were eliminated because exposure is minimal.
- Compounds known to degrade to non-toxic products due to physical, biological, chemical activities (e.g., photolysis, biodegradation, pump and treat, etc.) or that may have been produced by chemical synthesis during analysis (Aldol-condensation) were removed if no other requirements for inclusion exist.
- Compounds whose potential for toxicity was low (>5g/kg body weight) and whose point source concentrations was less than 1 ppm may be deleted.
- The list of contaminants (remaining and removed) was compared with the values in the EPA Region III screening document.
- The list of chemicals removed was reviewed to identify those whose toxic effects were exerted upon a common target organ, or have synergistic or additive effects. Toxicity, concentration, and any additive/synergistic effects due to concomitant exposure were examined, as well as structure-activity relationships or other chemical similarities. The

possible contribution to site risk was assessed to determine whether a compound should be returned to the CPC list.

- Class A/B carcinogens are included as CPCs.

Scientific rationale and/or documentation to support the decision to remove contaminants is given in Appendix E.II.

E.2.3.2 Results of Selecting CPCs

E.2.3.2.1 Surface Soil

Tables E.2-2 and E.2-3 list the CPCs for radionuclides and chemicals, respectively. These tables contain only those constituents which have been selected for quantitative evaluation in this assessment. A complete list of analytes and the rationale for their exclusion is presented in Attachment E.II of this Appendix.

E.2.3.2.2 Waste Pit 1

The CPCs for waste pit material in Waste Pit 1 are contained in Tables E.2-4 (radionuclides) and E.2-5 (chemicals). Only those constituents that have been selected for quantitative evaluation in this assessment are included. A complete list of analytes and the rationale for their exclusion is presented in Attachment E.II of this Appendix.

E.2.3.2.3 Waste Pit 2

Tables E.2-6 and E.2-7 present the radionuclide and chemical CPCs for Waste Pit 2. These tables contain only those constituents that are evaluated quantitatively in the risk assessment. Attachment E.II of this Appendix contains a complete list of analytes and the rationale for their exclusion.

E.2.3.2.4 Waste Pit 3

Tables E.2-8 and E.2-9 present the CPCs in Waste Pit 3 for radionuclides and chemicals, respectively. These tables contain only those constituents which have been selected for quantitative evaluation in this assessment. The complete list of analytes and the rationale for their exclusion is presented in Attachment E.II of this Appendix.

E.2.3.2.5 Waste Pit 4

Tables E.2-10 and E.2-11 present the radionuclide and chemical CPCs, respectively for Waste Pit 4. Only those constituents selected for quantitative evaluation are included. Attachment E.II of this Appendix contains a complete list of analytes and the rationale for their exclusion.

4787

E.2.3.2.6 Waste Pit 5

Tables E.2-12 and E.2-13 present the CPCs in Waste Pit 5 for radionuclides and chemicals, respectively. The CPCs in Waste Pit 5 standing water are contained in Tables E.2-14 (radionuclides) and E.2-15 (chemicals). These tables contain only those constituents that are quantitatively evaluated in this assessment. A complete list of analytes and the rationale for their exclusion is presented in Attachment E.II of this Appendix.

E.2.3.2.7 Waste Pit 6

Tables E.2-16 through E.2-19 contain the CPCs for Waste Pit 6 sludge and standing water. These tables contain only those constituents which have been selected for quantitative evaluation in this assessment. A complete list of analytes and the rationale for their exclusion is contained in Attachment E.II of this Appendix.

E.2.3.2.8 Burn Pit

Tables E.2-20 and E.2-21 list the CPCs in Waste Pit 4 for radionuclides and chemicals, respectively. These tables contain only those constituents which have been selected for quantitative evaluation in this assessment. A complete list of analytes and the rationale for their exclusion is presented in Attachment E.II of this Appendix.

E.2.3.2.9 Clearwell

Tables E.2-22 through E.2-25 contain the radiological and chemical CPCs for the Clearwell sludge and standing water. Only those constituents that are quantitatively evaluated in this assessment are included. Attachment E.II of this Appendix contains a complete list of analytes and the rationale for their exclusion.

0412

TABLE E-2-1
DATA USED FOR THE OPERABLE UNIT 1
RISK ASSESSMENT

4788

Source	Medium	Data		
		Radiological	Chemical	Justification
Pit 1	Waste	Weston CIS Borings	Weston CIS Borings	Validated Data Available
		ASI/TT RI/FS Borings	ASI/TT RI/FS Borings	Validated Data Available
Pit 2	Waste	Weston CIS Borings	Weston CIS Borings	Validated Data Available
		ASI/TT RI/FS Borings	ASI/TT RI/FS Borings	Validated Data Available
Pit 3	Waste	Weston CIS Borings	Weston CIS Borings	Validated Data Available
		ASI/TT RI/FS Borings	ASI/TT RI/FS Borings	Validated Data Available
Pit 4	Waste	Weston CIS Borings	Weston CIS Borings	Validated Data Available
		ASI/TT RI/FS Borings	ASI/TT RI/FS Borings	Validated Data Available
Pit 5	Waste	Weston CIS Grab Samples	Weston CIS Grab Samples	Validated Data Available
		WEMCO RI/FS Grab Samples	WEMCO RI/FS Grab Samples	Validated Data Available
	Standing Water	Weston CIS Grab Samples	Weston CIS Grab Samples	Validated Data Available
Pit 6	Waste	Weston CIS Grab Samples	Weston CIS Grab Samples	Validated Data Available
		WEMCO RI/FS Grab Samples	WEMCO RI/FS Grab Samples	Validated Data Available
	Standing Water	Weston CIS Grab Samples	Weston CIS Grab Samples	Validated Data Available
Burn Pit	Waste	Weston CIS Borings	Weston CIS Borings	Validated Data Available
		ASI/TT RI/FS Borings	ASI/TT RI/FS Borings	Validated Data Available
Clearwell	Waste	Weston CIS Grab Samples	Weston CIS Grab Samples	Validated Data Available
		WEMCO RI/FS Grab Samples	WEMCO RI/FS Grab Samples	Validated Data Available
	Standing Water	Weston CIS Grab Samples	Weston CIS Grab Samples	Validated Data Available
Surface Soil	Soil	Weston CIS Grab Samples	RI/FS Grab Samples	Validated Data Available
		RI/FS Grab Samples	RI/FS Grab Samples	Validated Data Available

TABLE E.2-2

RADIOLOGICAL CPCs IN SURFACE SOIL (pCi/g)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Cesium-137	31/60	6.00	1.00	1.00	0/7	ND*			1.00
Neptunium-237	1/60	0.500	0.100	0.500	0/7	ND			0.500
Plutonium-238	11/60	4.10	0.400	0.400	0/7	ND			0.400
Plutonium-239/240	10/60	0.800	0.100	0.100	0/7	ND			0.100
Radium-226					5/7	1.20	1.00	1.00	1.00
Radium-228					5/7	1.80	1.20	1.20	1.20
Strontium-90	3/60	1.70	0.400	1.70	2/7	0.600	0.400	0.600	1.70
Technetium-99	18/60	93.0	8.70	8.70	1/7	0.900	0.600	0.900	8.70
Thorium-228	50/60	48.0	5.50	5.50	7/7	2.20	1.60	1.60	5.50
Thorium-230	59/60	972	74.9	74.9	7/7	6.10	3.90	3.90	74.9
Thorium-232	48/60	38.0	4.30	4.30	7/7	1.30	1.10	1.10	4.30
Uranium-234	60/60	298	60.1	60.1	7/7	5.30	4.20	4.20	60.1
Uranium-235	60/60	51.0	6.80	6.80	1/7	0.800	0.50	0.800	6.80
Uranium-238	60/60	1500	245	245	7/7	16.1	11.5	11.5	245

*ND - Not detected.

TABLE E.2-3
CHEMICAL CPCs IN SURFACE SOIL

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Organics (g/kg)									
Aroclor-1254					3/16	1400	310	1400	1400
Inorganics (mg/kg)									
Antimony					16/16	32.5	27.2	27.2	27.2
Arsenic					16/16	6.40	4.90	4.90	4.90
Barium					16/16	92.3	56.9	56.9	56.9
Beryllium					16/16	1.00	0.800	0.800	0.800
Cadmium					16/16	7.70	5.80	5.80	5.80
Chromium					16/16	18.8	14.3	14.3	14.3
Cobalt					16/16	17.0	10.4	10.4	10.4
Copper					16/16	20.1	17.0	17.0	17.0
Lead					16/16	34.3	15.9	15.9	15.9
Manganese					16/16	759	574	574	574
Molybdenum					15/16	5.70	4.30	4.30	4.30
Nickel					16/16	50.2	29.4	29.4	29.4
Silver					16/16	10.3	8.90	8.90	8.90
Uranium					5/5	62.0	52.2	52.2	52.2
Vanadium					16/16	26.9	19.6	19.6	19.6
Zinc					16/16	79.9	46.7	46.7	46.7

178

E-2-14

0415

TABLE E.2-4

RADIOLOGICAL CPCs IN WASTE PIT 1 - SOLID CONTENTS (pCi/g)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL	REPRESENTATIVE CONCENTRATION	
Cesium-137	1/5	1.10	0.800	1.10	0/6	ND ^a			1.10
Radium-226					5/6	99.6	86.7	86.7	86.7
Radium-228					5/6	41.0	35.1	35.1	35.1
Strontium-90	0/5	ND			5/6	7.69	4.70	4.70	4.70
Technetium-99	1/5	15.0	9.70	15.0	1/6	1.10	0.800	1.10	15.0
Thorium-228	5/5	52.0	37.8	37.8	1/4	131	433	131	131
Thorium-230	5/5	3600	2800	2800	3/4	5460	6660	5460	5460
Thorium-232	5/5	55.0	39.8	39.8	1/4	131	246	131	131
Uranium-234	5/5	1180	902	902	4/4	830	795	795	902
Uranium-235	5/5	151	108	108	5/5	259	179	179	179
Uranium-238	5/5	6980	4660	4660	5/5	16200	10400	10400	10400

^aND - Not detected

4282

E-2-15

0416

TABLE E.2-5

CHEMICAL CPCs IN WASTE PIT 1 - SOLID CONTENTS

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL	REPRESENTATIVE CONCENTRATION	
Organics (g/kg)									
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin					5/6	1.20	0.770	0.770	0.770
1,2,3,4,6,7,8-Heptachlorodibenzofuran					5/6	1.20	0.800	0.800	0.800
1,2,3,4,7,8-Hexachlorodibenzofuran					3/6	0.830	0.660	0.830	0.830
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin					4/6	0.770	0.520	0.520	0.520
1,2,3,6,7,8-Hexachlorodibenzofuran					3/6	0.290	0.230	0.290	0.290
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin					3/6	0.530	0.340	0.530	0.530
1,2,3,7,8-Pentachlorodibenzofuran					5/6	1.20	0.730	0.730	0.730
2,3,4,6,7,8-Hexachlorodibenzofuran					3/6	0.410	0.320	0.410	0.410
2,3,4,7,8-Pentachlorodibenzofuran					4/6	1.20	0.750	0.750	0.750
2,3,7,8-Tetrachlorodibenzofuran					5/6	14.0	7.64	7.64	7.64
Heptachlorodibenzo-p-dioxin					5/6	2.30	1.45	1.45	1.45
Heptachlorodibenzofuran					5/6	2.70	1.75	1.75	1.75
Hexachlorodibenzo-p-dioxin					5/6	4.90	3.21	3.21	3.21
Hexachlorodibenzofuran					4/6	2.90	2.26	2.26	2.26
Octachlorodibenzo-p-dioxin					5/6	0.74	0.540	0.540	0.540
Octachlorodibenzofuran					3/6	0.760	0.460	0.760	0.760
Pentachlorodibenzofuran					5/6	7.90	4.69	4.69	4.69
Tetrachlorodibenzofuran					6/6	35.0	20.7	20.7	20.7
4,4-DDT	1/6	1600	934	1600	0/5	ND ^a			1600
Aroclor-1221					1/5	4600	4120	4120	4600

TABLE E.2-5

(Continued)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL	REPRESENTATIVE CONCENTRATION	
Aroclor-1248	1/6	3500	2540	3500	5/6	10000	7070	7070	7070
Aroclor-1254	6/6	11500	9980	9978	5/5	10000	9250	9250	9980
Aroclor-1260	2/6	7800	6110	7800	0/5	ND			7800
Benzo(a)anthracene	3/6	180	245	180	0/8	ND			180
Benzo(a)pyrene	1/6	140	257	140	0/7	ND			140
Benzo(b)fluoranthene	5/6	330	307	307	0/8	ND			307
Benzo(k)fluoranthene	1/6	140	257	140	0/8	ND			140
Chrysene	5/6	540	451	451	0/8	ND			451
Dichlorodifluoromethane					1/2	29600	107900	29600	29600
Fluoranthene	6/6	430	340	340	2/8	1000	532	1000	1000
Phenanthrene	6/6	2400	1880	1880	5/8	2100	1140	1140	1880
Tetrachloroethene	1/5	120	120	120	6/9	650	252	252	252
Tributyl phosphate					3/3	25000	32600	25000	25000
Inorganics (mg/kg)									
Antimony	1/6	0.400	0.963	0.400	6/6	125	88.9	88.9	88.9
Arsenic	6/6	15.0	11.3	11.3	5/6	1.70	1.70	1.70	11.3
Barium	6/6	395	374	374	6/6	439	405	405	405
Beryllium	5/6	2.20	1.81	1.81	6/6	12.5	8.21	8.21	8.21
Boron					4/5	1650	1220	1220	1220
Cadmium	5/6	5.00	3.32	3.32	6/6	18.5	16.2	16.2	16.2
Chromium	6/6	46.0	30.1	30.1	6/6	347	226	226	226

TABLE E.2-5

(Continued)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL	REPRESENTATIVE CONCENTRATION	
Cobalt	3/6	28.0	16.7	28.0	6/6	46.8	33.8	33.8	33.8
Copper	1/6	20.0	47.2	20.0	6/6	113	80.0	80.0	80.0
Cyanide	0/6	ND			3/6	0.730	0.450	0.730	0.730
Lead	1/6	17.0	28.7	17.0	5/5	53.4	36.6	36.6	36.6
Manganese	6/6	2910	2130	2130	6/6	3720	2037	2037	2030
Mercury	1/6	0.300	0.182	0.300	0/6	ND			0.300
Molybdenum					6/6	32.7	25.7	25.7	25.7
Nickel	6/6	65.0	41.8	41.8	6/6	57.4	47.1	47.1	47.1
Silver	4/6	33.0	17.8	17.8	6/6	189	122	122	122
Thallium	1/6	0.300	0.220	0.300	1/6	0.460	0.350	0.460	0.460
Uranium					6/6	48500	35000	35000	35000
Vanadium	6/6	67.0	48.3	48.3	6/6	142	95.7	95.7	95.7
Zinc	4/6	58.0	36.7	36.7	6/6	24.9	19.31	19.31	36.7

*ND - Not detected

TABLE E.2-6

RADIOLOGICAL CPCs IN WASTE PIT 2 - SOLID CONTENTS (pCi/g)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Cesium-137	2/5	3.60	2.50	3.60	2/4	0.500	0.700	0.500	3.60
Plutonium-238	2/5	0.100	0.100	0.100	0/4	ND*			0.100
Plutonium-239/240	2/5	0.600	0.400	0.600	0/4	ND			0.600
Radium-226					4/4	951	850	850	850
Radium-228					4/4	437	382	382	382
Ruthenium-106	0/5	ND			2/4	4.70	6.00	4.70	4.70
Strontium-90	0/5	ND			3/4	3.99	4.40	3.99	3.99
Technetium-99	3/5	618	390	618	1/4	1.64	1.40	1.64	618
Thorium-228	5/5	164	121	121	2/2	697	912	697	697
Thorium-230	5/5	3980	2990	2990	2/2	18400	60300	18400	18400
Thorium-232	5/5	88.0	69.5	69.5	1/2	268	528	268	268
Uranium-234	5/5	18200	11500	11500	2/2	1651	5370	1651	11500
Uranium-235	5/5	8780	5520	5520	2/2	130	426	130	5520
Uranium-238	5/5	17900	11900	11900	2/2	1860	6064	1860	11900

*ND - Not detected

42874

E-2-19

0420

TABLE E.2-7

CHEMICAL CPCs IN WASTE PIT 2 - SOLID CONTENTS

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Organics (µg/kg)									
1,2,3,4,6,7,8-Heptachlorodibenzofuran					1/4	1.00	0.866	1.00	1.00
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin					2/4	3.80	3.30	3.80	3.80
1,2,3,4,7,8-Hexachlorodibenzofuran					1/4	0.260	0.256	0.260	0.260
Heptachlorodibenzofuran					3/4	5.90	5.12	5.90	5.90
Heptachlorodibenzo-p-dioxin					3/4	8.10	7.05	8.10	8.10
Hexachlorodibenzofuran					2/4	2.70	2.28	2.70	2.70
Hexachlorodibenzo-p-dioxin					1/4	0.320	0.367	0.320	0.320
Octachlorodibenzofuran					3/4	4.90	4.30	4.90	4.90
Octachlorodibenzo-p-dioxin					3/4	45.9	40.3	45.9	45.9
Pentachlorodibenzofuran					1/4	0.550	0.481	0.550	0.550
2-Methylnaphthalene	2/5	7000	4500	7000	3/7	7800	4980	7800	7800
4-Nitroaniline	1/5	4900	4210	4900	0/7	ND*			4900
4-Nitrophenol	0/5	ND			1/7	190	6150	190	190
4,4'-DDT	2/5	1400	1040	1400					1400
Acenaphthene	2/5	1200	876	1200	3/7	31000	20000	31000	31000
Acenaphthylene	1/5	43000	27100	43000	1/7	110	1280	110	43000
Anthracene	4/5	120000	75600	75600	3/7	56000	30800	56000	75600
Aroclor-1248	1/5	321	1750	321	2/4	4900	4320	4900	4900
Aroclor-1254	1/5	323	3360	323	0/4	ND			323
Benzene	0/4	ND			1/11	4.00	8.90	4.00	4.00
Benzo(a)anthracene	5/5	130000	82000	82000	3/7	100000	62200	100000	100000

TABLE E.2-7
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Benzo(a)pyrene	4/5	120000	75700	75700	3/7	68000	43700	68000	75700
Benzo(b)fluoranthene	5/5	10000	7410	7410	3/7	130000	55600	130000	130000
Benzo(g,h,i)perylene	3/5	42000	26500	42000	3/7	42000	27300	42000	42000
Benzo(k)fluoranthene	4/5	75000	47300	47300	3/7	44000	25600	44000	47300
Chrysene	5/6	130000	65900	65900	2/7	86000	46200	86000	86000
Dibenzofuran	3/5	36000	22700	36000	3/7	21000	13700	21000	36000
Dibenzo(a,h)anthracene	2/5	16000	10200	16000	3/7	20000	11000	20000	20000
Fluoranthene	5/5	490000	309000	309000	5/7	280000	158000	158000	309000
Fluorene	3/5	62000	39100	62000	3/7	37000	23200	37000	62000
Indeno(1,2,3-cd)pyrene	3/5	46000	29100	46000	3/7	37000	23500	37000	46000
Naphthalene	3/5	16000	10300	16000	3/7	23000	14300	23000	23000
Pentachlorophenol	0/5	ND			2/7	1600	5530	1600	1600
Phenanthrene	4/4	18000	15200	15200	5/7	280000	156000	156000	156000
Pyrene	5/5	250000	158000	158000	5/7	230000	132000	132000	158000
Tetrachloroethene	0/4	ND			1/11	45.0	17.0	45.0	45.0
Tributyl phosphate					4/4	39000	41700	39000	39000
Vinyl chloride	1/4	670	622	670	6/11	1900	724	724	724
Inorganics (mg/kg)									
Antimony	2/5	1.20	0.995	1.20	4/4	55.4	58.8	55.4	55.4
Arsenic	5/5	10.0	7.51	7.51	4/4	423	380	380	380
Barium	5/5	208	174	174	4/4	1920	1960	1920	1920
Beryllium	5/5	8.90	6.40	6.40	4/4	26.9	26.8	26.8	26.8
Boron					4/4	238	248	238	238

TABLE E.2-7
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Cadmium	5/5	9.60	7.92	7.92	4/4	12.8	13.5	12.8	12.8
Chromium	5/5	91.0	67.4	67.4	4/4	282	294	282	282
Cobalt	5/5	451	295	295	4/4	1470	1320	1320	1320
Copper	5/5	329	222	222	4/4	1340	1260	1260	1260
Cyanide	0/5	ND			4/4	2.90	2.64	2.64	2.64
Lead	5/5	190	140	140	4/4	758	848	758	758
Manganese	5/5	917	846	846	4/4	2850	2660	2660	2660
Mercury	4/5	0.700	0.581	0.581	4/4	2.60	2.81	2.60	2.60
Molybdenum					4/4	215	193	193	193
Nickel	5/5	609	404	404	4/4	1740	1580	1580	1580
Selenium	3/5	10.0	6.67	10.0	4/4	131	114	114	114
Silver	3/5	23.0	17.1	23.0	4/4	42.5	41.0	41.0	41.0
Thallium	0/5	ND			1/4	2.40	2.10	2.40	2.40
Vanadium	5/5	106	82.5	82.5	4/4	594	529	529	529
Zinc	5/5	3250	2070	2070	4/4	488	468	468	2070

*ND - Not detected

E-2-20423

4287

TABLE E.2-8
RADIOLOGICAL CPCs IN WASTE PIT 3 - SOLID CONTENTS (pCi/g)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Neptunium-237	3/7	2.10	1.10	2.10					2.10
Plutonium-238	3/7	1.00	0.500	1.00	1/5	0.980	0.700	0.980	1.00
Plutonium-239/240	3/7	14.0	6.00	14.0	2/5	1.59	1.40	1.59	14.0
Radium-226					6/6	451	306	306	306
Radium-228					6/6	241	186	186	186
Strontium-90	1/7	5.20	2.60	5.20	4/6	4.91	2.80	2.80	5.20
Technetium-99	6/7	1110	521	521	6/6	33	22.7	22.7	521
Thorium-228	7/7	40.0	21.6	21.6	3/5	554	526	554	554
Thorium-230	7/7	11700	8320	8320	6/6	11400	8570	8570	8570
Thorium-232	7/7	59.0	30.7	30.7	3/5	396	334	396	396
Uranium-234	7/7	475	327	327	4/4	991	1110	991	991
Uranium-235	7/7	21.0	16.6	16.6	1/1	51.8		51.8	51.8
Uranium-235/236					4/4	89.2	73.0	73.0	73.0
Uranium-238	7/7	1380	762	762	6/6	1740	1290	1290	1290

E-2-23
0424

TABLE E.2-9

CHEMICAL CPCs IN WASTE PIT 3 - SOLID CONTENTS

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin					5/6	1.70	1.12	1.12	1.12
1,2,3,4,6,7,8-Heptachlorodibenzofuran					3/6	0.210	0.164	0.210	0.210
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin					1/6	0.048	0.256	0.048	0.048
Heptachlorodibenzo-p-dioxin					5/6	3.20	2.10	2.10	2.10
Heptachlorodibenzofuran					5/6	0.950	0.687	0.687	0.687
Hexachlorodibenzo-p-dioxin					1/6	0.260	0.180	0.260	0.260
Hexachlorodibenzofuran					4/6	0.350	0.267	0.267	0.267
Octachlorodibenzo-p-dioxin					6/6	19.4	12.7	12.7	12.7
Octachlorodibenzofuran					5/6	1.10	0.745	0.745	0.745
Tetrachlorodibenzofuran					1/6	0.200	0.117	0.200	0.200
Aroclor-1248	0/5	ND ^a			4/6	4800	2730	2730	2730
Aroclor-1254	1/5	140	331	140	5/6	3400	2080	2080	2080
Benzo(a)anthracene	1/7	60.0	394	60.0	1/7	360	471	360	360
Benzo(a)pyrene	0/7	ND			1/7	280	467	280	280
Benzo(b)fluoranthene	1/7	110	391	110	1/7	560	510	560	560
Benzo(g,h,i)perylene	0/7	ND			1/7	160	470	160	160
Chrysene	1/7	75.0	393	75.0	1/7	370	472	370	370
Indeno(1,2,3-cd)pyrene	0/7	ND			1/7	130	472	130	130
Pentachlorophenol	2/6	1300	1470	1300	5/5	1000	783	783	1300

TABLE E.2-9

(Continued)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Inorganics (mg/kg)									
Antimony	2/7	18.0	10.0	18.0	4/6	63.5	52.5	52.5	52.5
Arsenic	7/7	3050	1800	1800	6/6	37200	21300	21300	21300
Barium	7/7	14400	8080	8080	6/6	3570	2540	2540	8080
Beryllium	7/7	24.0	14.4	14.4	6/6	10.7	8.64	8.64	14.4
Boron					4/6	236	155	155	155
Cadmium	7/7	13.0	8.46	8.46	6/6	38.6	25.9	25.9	25.9
Chromium	7/7	152	110	110	6/6	234	186	186	186
Cobalt	7/7	21.0	17.5	17.5	6/6	50.7	36.0	36.0	36.0
Copper	4/7	2330	1670	1670	6/6	2010	1740	1740	1740
Cyanide	0/6	ND			4/6	1.70	1.61	1.61	1.61
Lead	5/7	613	358	358	6/6	837	670	670	670
Manganese	7/7	10600	5120	5120	6/6	20200	16700	16700	16700
Mercury	5/7	4.00	2.00	2.00	5/6	5.10	3.19	3.19	3.19
Molybdenum					6/6	284	241	241	241
Nickel	7/7	504	266	266	6/6	292	206	206	266
Selenium	5/7	90.0	49.5	49.5	5/6	6.00	4.29	4.29	49.5
Silver	4/7	8.10	6.62	6.62	6/6	41.8	37.4	37.4	37.4
Thallium	3/7	12.0	6.40	12.0	4/6	4.10	3.15	3.15	12.0
Tin					1/5	191	134	191	191
Uranium					6/6	5940	4560	4560	4560

4282

E-2-25

0426

TABLE E.2-9

(Continued)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Vanadium	7/7	9700	5200	5200	6/6	2200	1890	1890	5200
Zinc	3/7	311	168	311	6/6	325	211	211	311

*ND - Not detected

0427

E-2-26

4282

TABLE E.2-10

RADIOLOGICAL CPCs IN WASTE PIT 4 - SOLID CONTENTS (pCi/g)

4987
2827

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Neptunium-237	1/4	0.400	0.400	0.400					0.400
Plutonium-238	2/4	0.500	0.500	0.500					0.500
Plutonium-239/240	1/4	0.400	0.300	0.400					0.400
Radium-226					5/6	50.1	36.6	36.6	36.6
Radium-228					6/6	141	99.7	99.7	99.7
Strontium-90	0/4	ND*			5/6	144	99.4	99.4	99.4
Technetium-99	4/4	225	197	197	5/6	9.43	6.60	6.60	197
Thorium-228	4/4	395	335	335	4/4	2470	2320	2320	2320
Thorium-230	4/4	566	620	566	6/6	1820	1520	1520	1520
Thorium-232	4/4	92.0	80.2	80.2	4/4	838	708	708	708
Uranium-234	4/4	2320	1990	1990	3/3	4100	6060	4100	4100
Uranium-235	4/4	426	368	368	1/1	26.6		26.6	368
Uranium-235/236					4/4	934	898	898	898
Uranium-238	4/4	15800	13400	13400	4/4	41900	44500	41900	41900

*ND - Not detected

E-2-27

0428

TABLE E.2-11

CHEMICAL CPCs IN WASTE PIT 4 - SOLID CONTENTS

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Organics (g/kg)									
1,2,3,4,7,8,9-Heptachlorodibenzofuran					3/6	2.40	1.59	2.40	2.40
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin					1/6	0.060	0.689	0.060	0.060
1,2,3,4,7,8-Hexachlorodibenzofuran					5/6	2.90	1.80	1.80	1.80
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin					2/6	0.160	0.564	0.160	0.160
1,2,3,6,7,8-Hexachlorodibenzofuran					5/6	1.10	0.830	0.830	0.830
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin					2/6	0.220	0.476	0.220	0.220
1,2,3,7,8,9-Hexachlorodibenzofuran					3/6	0.750	1.04	0.750	0.750
1,2,3,7,8-Pentachlorodibenzofuran					5/6	2.10	1.39	1.39	1.39
2,3,4,6,7,8-Hexachlorodibenzofuran					4/6	1.20	0.814	0.814	0.814
2,3,4,7,8-Pentachlorodibenzofuran					5/6	2.70	1.74	1.74	1.74
2,3,7,8-Tetrachlorodibenzofuran					5/6	9.90	6.97	6.97	6.97
Heptachlorodibenzo-p-dioxin					5/6	4.00	3.16	3.16	3.16
Heptachlorodibenzofuran					5/6	4.40	3.18	3.18	3.18
Hexachlorodibenzo-p-dioxin					4/6	2.70	1.85	1.85	1.85
Hexachlorodibenzofuran					5/6	8.50	5.39	5.39	5.39
Octachlorodibenzo-p-dioxin					5/6	9.00	6.52	6.52	6.52
Octachlorodibenzofuran					4/6	4.90	3.66	3.66	3.66
Pentachlorodibenzofuran					5/6	15.3	9.42	9.42	9.42
Tetrachlorodibenzo-p-dioxin					2/6	0.470	0.316	0.470	0.470
Tetrachlorodibenzofuran					6/6	34.1	24.1	24.1	24.1

TABLE E.2-11

(Continued)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
4-Nitrophenol	1/4	2300	2110	2300	0/9	ND			2300
Acenaphthene	2/4	1200	1040	1200	2/9	1900	904	1900	1900
Anthracene	3/4	2500	2160	2500	2/9	2700	1180	2700	2700
Aroclor-1242	2/4	1030	904	1030	0/6	ND ^a			1030
Aroclor-1248	2/4	854	808	854	4/6	7500	5920	5920	5920
Aroclor-1254	4/4	1010	942	942	3/6	6800	4190	6800	6800
Benzene	0/4	ND			1/11	14.0	5.83	14.0	14.0
Benzo(a)anthracene	4/4	4100	3530	3530	2/9	4700	2000	4700	4700
Benzo(a)pyrene	3/4	4500	3840	4500	2/9	2900	1310	2900	4500
Benzo(b)fluoranthene	3/4	3800	3240	3800	2/9	5200	2360	5200	5200
Benzo(g,h,i)perylene	2/4	170	242	170	1/9	990	691	990	990
Benzo(k)fluoranthene	3/4	3700	3170	3700	0/9	ND			3700
Chrysene	4/4	4500	3860	3860	2/9	3300	1580	3300	3860
Dibenzofuran	3/4	1400	1200	1400	2/9	1200	638	1200	1400
Dibenzo(a,h)anthracene	1/4	65.0	273	65.0	0/9	ND			65.0
Fluoranthene	4/4	9900	8570	8570	2/9	11000	4210	11000	11000
Fluorene	3/4	2200	1880	2200	2/9	2000	951	2000	2200
Indeno(1,2,3-cd)pyrene	3/4	180	224	180	1/9	990	691	990	990
Naphthalene	3/4	1100	950	1100	2/9	740	450	740	1100
Phenanthrene	3/4	9400	8130	9400	2/9	12000	4750	12000	12000
Pyrene	4/4	6600	5710	5710	2/9	9000	3475	9000	9000

4282

E-2-29

0430

TABLE E.2-11

(Continued)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Tetrachloroethene	2/4	30000	25200	30000	6/10	240	82.5	82.5	30000
Tributyl phosphate					2/2	72000	136000	72000	72000
Vinyl chloride	0/4	ND			2/11	14.0	8.90	14.0	14.0
Inorganics (mg/kg)									
Antimony	1/5	0.500	0.375	0.500	4/5	317	222	222	222
Arsenic	1/5	4.60	2.99	4.60	5/5	6.50	5.16	5.16	5.16
Barium	5/5	6670	4580	4580	5/5	3720	3130	3130	4580
Beryllium	5/5	13.0	8.35	8.35	3/5	50.6	36.7	50.6	50.6
Boron					5/5	1010	658	658	658
Cadmium	4/5	29.0	18.6	18.6	5/5	34.8	24.5	24.5	24.5
Chromium	5/5	94.0	63.7	63.7	5/5	1500	1050	1050	1050
Cobalt	3/5	84.0	54.5	84.0	4/5	183	129	129	129
Copper	5/5	188	130	130	5/5	482	352	352	352
Cyanide	1/5	0.700	0.551	0.700	2/5	0.240	0.304	0.240	0.551
Lead	5/5	63.0	55.3	55.3	5/5	63.2	53.6	53.6	55.3
Manganese	5/5	3600	3340	3340	5/5	5620	4750	4750	4750
Mercury	3/5	0.600	0.487	0.600	3/5	0.620	0.454	0.620	0.620
Molybdenum					5/5	95.6	69.8	69.8	69.8
Nickel	5/5	50.0	38.2	38.2	5/5	223	167	167	167
Selenium	0/4	ND			1/5	0.370	0.316	0.370	0.370
Silver	4/5	444	279	279	5/5	755	531	531	531

TABLE E.2-11

(Continued)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Tin	4/4	87.0	82.8	82.8	4/5	133	114	114	114
Uranium					6/6	116000	94400	94400	94400
Vanadium	4/5	235	153	153	5/5	558	394	394	394
Zinc	4/5	84.0	63.4	63.4	5/5	200	143	143	143

*ND - Not detected

E-2-31

0432

TABLE E.2-12

RADIOLOGICAL CPCs IN WASTE PIT 5 - SOLID CONTENTS (pCi/g)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Cesium-137	2/6	76.0	52.8	76.0	9/9	78.0	40.2	40.2	76.0
Neptunium-237	5/6	19.0	15.1	15.1	2/2	46.0	80.5	46.0	46.0
Plutonium-238	5/6	4.40	3.60	3.60	3/9	0.300	0.100	0.300	3.60
Plutonium-239/240	5/6	13.0	9.70	9.70	5/9	3.72	1.20	1.20	9.70
Radium-226					9/9	150	112	112	112
Radium-228					8/9	39.0	26.7	26.7	26.7
Ruthenium-106	0/6	ND ^a			2/9	1.60	1.40	1.60	1.60
Strontium-90	6/6	31.0	20.1	20.1	8/9	15.0	6.80	6.80	20.1
Technetium-99	6/6	2990	2070	2070	9/9	3020	2020	2020	2070
Thorium-228	6/6	44.0	42.9	42.9	9/9	38.0	19.9	19.9	42.9
Thorium-230	6/6	8480	6810	6810	9/9	2600	900	900	6810
Thorium-232	6/6	55.0	45.1	45.1	7/9	10.0	4.70	4.70	45.1
Uranium-234	6/6	1250	929	929	9/9	860	713	713	929
Uranium-235	6/6	79.0	53.9	53.9	4/9	39.0	24.6	24.6	53.9
Uranium-238	6/6	1230	903	903	9/9	960	746	746	903

^aND - Not detected

TABLE E.2-13

CHEMICAL CPCs IN WASTE PIT 5 - SOLID CONTENTS

4282

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Organics (g/kg)									
Aroclor-1248	2/6	550	1080	550					550
Aroclor-1254	2/6	750	2010	750					750
Inorganics (mg/kg)									
Antimony	4/5	64.0	51.7	51.7	9/9	88.1	47.5	47.5	51.7
Arsenic	4/5	2800	2150	2150	7/9	715	542	542	2150
Barium	5/5	36900	30200	30200	9/9	18100	13200	13200	30200
Beryllium	5/5	18.0	14.8	14.8	9/9	22.4	14.2	14.2	14.8
Cadmium	4/5	17.0	11.6	11.6	9/9	4.70	3.32	3.32	11.6
Chromium	5/5	141	116	116	9/9	98.0	78.9	78.9	116
Cobalt	4/5	44.0	35.5	35.5	9/9	17.1	12.1	12.1	35.5
Copper	4/5	18200	11800	11800	9/9	6450	4110	4110	11800
Cyanide	1/3	0.500	0.958	0.500	0/9	ND*			0.500
Lead	4/5	168	174	168	9/9	134	105	105	168
Manganese	5/5	3300	3050	3050	9/9	486	466	466	3050
Mercury	5/5	1.80	1.59	1.59	9/9	1.50	1.04	1.04	1.59
Molybdenum					9/9	1350	666	666	666
Nickel	5/5	202	150	150	9/9	178	119	119	150
Selenium	4/5	18.0	13.8	13.8	0/9	ND			13.8
Silver	3/5	9.40	7.81	9.40	5/9	22.2	14.1	14.1	14.1
Thallium	4/5	11.0	9.94	9.94	4/9	52.0	34.5	34.5	34.5

TABLE E.2-13

(Continued)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Tin	1/1	30.0		30.0	9/9	92.8	48.0	48.0	48.0
Uranium					9/9	3700	2760	2760	2760
Vanadium	5/5	5380	4920	4920	9/9	4530	2760	2760	4920
Zinc	3/5	180	166	180	9/9	278	206	206	206

*ND - Not detected

E-2-34

0435

4787

TABLE E.2-14

RADIOLOGICAL CPCs IN WASTE PIT 5 - SURFACE WATER (pCi/L)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Cesium-137	2/2	90.0	194	90.0					90.0
Strontium-90	2/2	41.0	59.6	41.0					41.0
Technetium-99	2/2	320	533	320					320
Thorium-230	2/2	0.100	0.100	0.100					0.100
Uranium-234	2/2	420	415	420					420
Uranium-235	2/2	19.0	18.5	19.0					19.0
Uranium-238	2/2	400	385	400					400

2824

E-2-35

0436

TABLE E.2-15

CHEMICAL CPCs IN WASTE PIT 5 - SURFACE WATER ($\mu\text{g/L}$)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Organics									
Benzene	1/2	11.0	33.6	11.0					11.0
Inorganics									
Antimony	2/2	4.50	6.10	4.50					4.50
Arsenic	2/2	2.10		2.10					2.10
Barium	2/2	108	119	108					108
Copper	2/2	21.0	23.7	21.0					21.0
Cyanide	2/2	87.0	140	87.0					87.0
Lead	2/2	2.90	6.60	2.90					2.90
Nickel	2/2	21.0	26.3	21.0					21.0
Selenium	1/2	2.10	5.40	2.10					2.10
Vanadium	2/2	47.0	49.7	47.0					47.0
Zinc	2/2	114	167	114					114

E-2-36

0437

48872

TABLE E.2-16

RADIOLOGICAL CPCs IN WASTE PIT 6 - SOLID CONTENTS (pCi/g)

1282

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Cesium-137	3/4	31.0	31.2	31.0	8/8	14.0	10.8	10.8	31.0
Neptunium-237	4/4	3.60	3.40	3.40					3.40
Plutonium-238	4/4	1.40	1.30	1.30	6/8	1.00	0.800	0.800	1.30
Plutonium-239/240	4/4	15.0	14.3	14.3	8/8	14.0	11.3	11.3	14.3
Radium-226					8/8	4.90	4.40	4.40	4.40
Radium-228					8/8	191	96.3	96.3	96.3
Strontium-90	4/4	5.10	5.50	5.10	6/8	4.80	3.70	3.70	5.10
Technetium-99	4/4	164	167	164	5/8	45.0	31.1	31.1	164
Thorium-228	4/4	1.20	1.10	1.10	8/8	1.70	1.50	1.50	1.50
Thorium-230	4/4	44.0	47.6	44.0	8/8	62.0	45.9	45.9	45.9
Thorium-232	4/4	1.20	1.10	1.10	8/8	1.00	0.700	0.700	1.10
Uranium-234	4/4	5330	5060	5060	8/8	4060	3120	3120	5060
Uranium-235	4/4	1750	1840	1750	8/8	337	267	267	1750
Uranium-238	4/4	18700	20500	18700	8/8	28700	20600	20600	20600

E-2-37

0438

TABLE E.2-17

CHEMICAL CPCs IN WASTE PIT 6 - SOLID CONTENTS

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Organics (g/kg)									
Aroclor-1254	1/1	81.0		81.0					81.0
Tetrachloroethene	4/4	29000	31100	29000					29000
Inorganics (mg/kg)									
Arsenic	1/1	7.60		7.60	9/9	76.7	54.9	54.9	54.9
Barium	1/1	95.0		95.0	9/9	71.7	58.6	58.6	95.0
Beryllium	1/1	5.70		5.70	9/9	2.10	1.42	1.42	5.70
Cadmium	1/1	5.70		5.70	1/9	1.30	2.65	1.30	5.70
Chromium	1/1	30.0		30.0	3/9	7.00	22.7	7.00	30.0
Cobalt	1/1	26.0		26.0	5/9	4.60	5.79	4.60	26.0
Copper	1/1	222		222	3/9	10.8	15.5	10.8	222
Lead	1/1	60.0		60.0	9/9	113	79.6	79.6	79.6
Manganese	1/1	35.0		35.0	9/9	312	221	221	221
Nickel	1/1	51.0		51.0	9/9	22.7	18.9	18.9	51.0
Silver	1/1	158		158	7/9	9.20	6.19	6.19	158
Thallium	0/1	ND*			6/9	108	71.0	71.0	71.0
Tin					7/9	21.5	13.8	13.8	13.8
Uranium					8/8	27700	19300	19300	19300

E-2-38

0439

TABLE E.2-17

(Continued)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Vanadium	1/1	100		100	0/9	ND			100
Zinc	1/1	48.0		48.0	9/9	61.0	44.7	44.7	48.0

*ND - Not detected

TABLE E.2-18

RADIOLOGICAL CPCs IN WASTE PIT 6 - SURFACE WATER (pCi/L)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Radium-228	5/5	31.3	25.7	25.7					25.7
Technetium-99	5/5	3500	2750	2750					2750
Thorium-230	2/5	0.300	0.300	0.300					0.300
Uranium-234	5/5	77.0	85.2	77.0					77.0
Uranium-235	5/5	9.30	9.90	9.30					9.30
Uranium-238	5/5	460	499	460					460

E-2-40

0441

4282

TABLE E.2-19

CHEMICAL CPCs IN WASTE PIT 6 - SURFACE WATER (g/L)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Antimony	1/5	1.70	1.30	1.70					1.70
Cyanide	1/5	10.0	8.10	10.0					10.0
Lead	1/5	2.90	2.00	2.90					2.90
Zinc	2/5	114	72.8	114					114

4282

E-2-41

F442

TABLE E.2-20

RADIOLOGICAL CPCs IN BURN PIT - SOLID CONTENTS (pCi/g)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Neptunium-237	2/6	0.600	0.500	0.600					0.600
Plutonium-238	1/6	0.500	0.300	0.500	0/4	ND*			0.500
Plutonium-239/240	1/6	0.400	0.200	0.400	0/4	ND			0.400
Radium-226					4/4	39.2	34.2	34.2	34.2
Radium-228					4/4	10.4	11.2	10.4	10.4
Strontium-90	0/6	ND			1/4	0.500		0.500	0.500
Technetium-99	4/6	64.0	52.3	52.3	4/4	3.29	3.00	3.00	52.3
Thorium-228	6/6	19.0	12.9	12.9	3/4	12.4	378	12.4	12.9
Thorium-230	6/6	218	127	127	4/4	4530	3810	3810	3810
Thorium-232	6/6	21.0	13.2	13.2	3/4	14.4	173	14.4	14.4
Uranium-234	6/6	415	253	253	4/4	1710	1560	1560	1560
Uranium-235	6/6	27.0	16.1	16.1	4/4	102	101	101	101
Uranium-238	6/6	454	299	299	4/4	2000	1800	1800	1800

*ND - Not detected

TABLE E.2-21

CHEMICAL CPCs IN THE BURN PIT - SOLID CONTENTS (mg/kg)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Organics (g/kg)									
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin					2/4	0.520	0.556	0.520	0.520
Heptachlorodibenzo-p-dioxin					2/4	0.980	1.080	0.980	0.980
Octachlorodibenzo-p-dioxin					2/4	4.00	4.50	4.00	4.00
Octachlorodibenzofuran					1/4	0.130	0.191	0.130	0.130
Acenaphthene	0/6	ND ^a			1/5	1100	810	810	810
Anthracene	0/7	ND			1/5	3100	2050	3100	3100
Aroclor-1254	5/7	2700	1560	1560	3/4	7700	6690	7700	7700
Benzo(a)anthracene	4/7	170	209	170	2/5	6300	4030	6300	6300
Benzo(a)pyrene	1/7	160	246	160	2/5	3900	2530	3900	3900
Benzo(b)fluoranthene	4/7	170	210	170	1/5	9600	6120	9600	9600
Benzo(g,h,i)perylene	1/7	85.0	256	85.0	2/5	2900	1900	2900	2900
Benzo(k)fluoranthene	1/7	200	242	200	1/5	340	1660	340	340
Chrysene	3/7	83.0	221	83.0	2/5	7000	4470	7000	7000
Dibenzofuran	0/7	ND			1/5	900	689	900	900
Fluoranthene	3/7	210	243	210	2/5	16000	10100	16000	16000
Fluorene	0/7	ND			2/5	1700	1170	1700	1700
Indeno(1,2,3-cd)pyrene	1/6	78.0	257	78.0	2/5	2200	1460	2200	2200
Pentachlorophenol	2/7	2600	1780	2600	0/5	ND			2600
Phenanthrene	4/7	190	232	190	3/5	15000	9480	15000	15000
Pyrene	3/7	140	231	140	3/5	14000	8870	14000	14000
Tetrachloroethene	2/6	260	194	260	0/4	ND			260

E-2-43

0444

TABLE E.2-21

(Continued)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Vinyl chloride	0/6	ND			1/4	3.00	8.59	3.00	3.00
Inorganics (mg/kg)									
Antimony	1/7	0.600	0.664	0.600	2/4	17.8	18.0	17.8	17.8
Arsenic	5/7	21.0	11.8	11.8	4/4	39.2	34.7	34.7	34.7
Barium	5/7	7100	3050	3050	4/4	299	327	299	3050
Beryllium	5/7	16.0	7.14	7.14	4/4	1.90	2.01	1.90	7.14
Boron					2/3	48.2	61.3	48.2	48.2
Cadmium	7/7	35.0	15.4	15.4	4/4	5.40	5.61	5.40	15.4
Chromium	7/7	88.0	43.4	43.4	4/4	91.2	92.9	91.2	91.2
Cobalt	6/7	104	48.4	48.4	4/4	111	98.9	98.9	98.9
Copper	4/7	166	80.3	80.3	4/4	259	281	259	259
Cyanide	0/7	ND			2/4	0.210	0.199	0.210	0.210
Lead	5/7	53.0	32.4	32.4	4/4	279	310	279	279
Manganese	7/7	1720	859	859	4/4	962	944	944	944
Mercury	2/7	0.200	0.120	0.200	3/4	1.20	1.12	1.20	1.20
Molybdenum					4/4	24.8	24.9	24.8	24.8
Nickel	6/7	60.0	31.4	31.4	4/4	206	187	187	187
Selenium	1/6	0.500	0.347	0.500	4/4	2.00	1.91	1.91	1.91
Silver	2/6	506	255	506	4/4	21.6	23.5	21.6	506
Thallium	3/7	0.500	0.409	0.500	0/4	ND			0.500
Uranium					4/4	4460	4030	4030	4030

TABLE E.2-21

(Continued)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Vanadium	4/7	290	129	129	4/4	43.3	43.3	46.3	129
Zinc	7/7	75.0	57.8	57.8	4/4	505	523	505	505

*ND - Not Detected

E-2-45

446

TABLE E.2-22

RADIOLOGICAL CPCs IN THE CLEARWELL - SOLID CONTENTS (pCi/g)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Cesium-137	4/4	450	406	406	6/6	71.4	62.9	62.9	406
Neptunium-237	3/4	2.20	2.10	2.20	4/6	1.80	1.70	1.70	2.20
Plutonium-238	0/4				5/6	0.490	0.400	0.400	0.400
Plutonium-239/240	0/4				5/6	0.540	0.400	0.400	0.400
Radium-226					6/6	170	118	118	118
Radium-228					6/6	26.4	24.1	24.1	24.1
Strontium-90	4/4	26.0	22.3	22.3	2/6	12.8	7.20	12.8	22.3
Technetium-99	2/4	278	254	278	6/6	695	523	523	523
Thorium-228	4/4	56.0	54.9	54.9	6/6	28.1	26.8	26.8	54.9
Thorium-230	4/4	5600	4760	4760	6/6	314	233	233	4760
Thorium-232	4/4	39.0	36.9	36.9	6/6	9.69	7.70	7.70	36.9
Uranium-234	4/4	376	364	364	6/6	1050	797	797	797
Uranium-235	4/4	49.0	48.3	48.3	6/6	373	349	349	349
Uranium-238	4/4	670	683	683	6/6	1640	1360	1360	1360

E-2-46

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TABLE E.2-23

CHEMICAL CPCs IN THE CLEARWELL - SOLID CONTENTS

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Organics (g/kg)									
2,4,5-Trichlorophenol	1/4	6200	5980	6200					6200
Anthracene	1/4	450	711	450					450
Aroclor-1242	1/4	121	168	121					121
Aroclor-1248	1/4	308	284	308					308
Aroclor-1254	4/4	737	643	643					643
Benzo(a)anthracene	2/4	890	917	890					890
Benzo(a)pyrene	1/4	670	772	670					670
Benzo(b)fluoranthene	1/4	710	792	710					710
Benzo(g,h,i)perylene	1/4	230	725	230					230
Benzo(k)fluoranthene	1/4	750	814	750					750
Chrysene	3/4	1000	1000	1000					1000
Fluoranthene	1/4	3100	2700	3100					3100
Indeno(1,2,3-cd)pyrene	1/4	270	719	270					270
Phenanthrene	4/4	2100	1790	1790					1790
Pyrene	3/4	1400	1300	1400					1400

TABLE E.2-23

(Continued)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Inorganics (mg/kg)									
Antimony	2/4	32.0	27.0	32.0	4/6	10.9	9.41	9.41	32.0
Arsenic	4/4	18.0	16.6	16.6	5/6	59.1	54.0	54.0	54.0
Barium	4/4	6910	6140	6140	6/6	1790	1610	1610	6140
Beryllium	4/4	9.10	7.78	7.78	6/6	2.90	2.34	2.34	7.78
Cadmium	2/4	7.20	7.27	7.20	6/6	2.90	2.73	2.73	7.20
Chromium	4/4	76.0	70.7	70.7	6/6	196	153	153	153
Cobalt	2/4	23.0	23.8	23.0	6/6	25.7	21.4	21.4	23.0
Copper	4/4	1120	1050	1050	6/6	3320	2420	2420	2420
Cyanide	1/4	9.20	7.85	9.20	4/6	1.47	1.09	1.09	9.20
Lead	4/4	83.0	75.6	75.6	6/6	588	433	433	433
Manganese	4/4	1660	1660	1660	6/6	19800	13200	13200	13200
Mercury	4/4	4.40	4.80	4.40	6/6	1.60	1.41	1.41	4.40
Molybdenum					6/6	40.9	36.5	36.5	36.5
Nickel	4/4	67.0	64.8	64.8	6/6	228	167	167	167
Selenium	1/4	3.70	3.19	3.70	4/6	0.850	0.617	0.617	3.70
Silver	1/4	3.30	3.18	3.30	5/6	12.7	9.84	9.84	9.84
Thallium	1/4	2.10	1.82	2.10	4/6	1.60	1.26	1.26	2.10
Thorium					6/6	88.9	70.5	70.5	70.05
Tin					5/6	24.1	18.1	18.1	18.1
Uranium					6/6	2780	2090	2090	2090
Vanadium	4/4	2600	2200	2200	6/6	285	232	232	2200
Zinc	4/4	194	177	177	6/6	314	246	246	246

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TABLE E.2-24

RADIOLOGICAL CPCs IN THE CLEARWELL - SURFACE WATER (pCi/L)

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PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Radium-226	2/2	1.10		1.10					1.10
Technetium-99	2/2	4030	9480	4030					4030
Thorium-230	1/2	0.400	1.20	0.400					0.400
Uranium-234	2/2	1900	2170	1900					1900
Uranium-235	2/2	120	147	120					120
Uranium-238	2/2	6200	8330	6200					6200

E-2-49

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TABLE E.2-25

CHEMICAL CPCs IN THE CLEARWELL - SURFACE WATER ($\mu\text{g/L}$)

PARAMETER	CIS DATA				RI/FS DATA				CPC CONCENTRATION
	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	FREQ	MAX DET	UCL (95%)	REPRESENTATIVE CONCENTRATION	
Arsenic	2/2	4.20	6.60	4.20					4.20
Copper	2/2	19.0	32.3	19.0					19.0
Cyanide	1/2	87.0	305	87.0					87.0
Selenium	1/2	3.00	8.70	3.00					3.00
Silver	2/2	14.0	22.0	14.0					14.0
Vanadium	2/2	513	1810	513					513
Zinc	2/2	47.0	153	47.0					47.0

E-2-50

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E.3.0 HUMAN EXPOSURE ASSESSMENT

The exposure assessment defines and evaluates the route, magnitude, frequency, and duration of exposure of a population to site-related constituents of potential concern (CPC) (identified in Section E.2.0). Exposure levels for specific receptor populations are estimated by a combination of direct measurements of chemical concentrations in the environment and fate and transport modeling (Section 5.0 and Appendix D of the Remedial Investigation Report (RI) which predicts concentrations of site contaminants in environmental media at potential points of exposure. Human activity patterns are also a key determinant in predicting the nature and magnitude of potential exposures. Factors relating to human activity include the frequency of contact with contaminated media, exposure duration, and the types of activities in which a person engages. These elements of the exposure assessment are integrated to provide a quantitative estimate of chemical exposure, which is then combined with information from the toxicity assessment (Section E.4.0) to estimate potential health risks to receptor populations (Section E.5.0).

The general procedure for conducting an exposure assessment involves three stages:

- Characterize the physical setting
- Identify migration and exposure pathways
- Quantify exposure

In the first step, the general physical characteristics of the site and characteristics of potential receptor populations are described. Site characteristics such as climate, vegetation, and hydrogeology are summarized in Section E.3.2. Land use and demographic information are also evaluated to identify and characterize current and potential future (hypothetical) receptor populations. In the second step of the exposure analysis, the predominant migration and exposure pathways are identified. Pathways are identified on the basis of specific sources, releases, types, and locations of chemicals at the site; environmental fate of chemical and radioactive constituents; and locations and activities of potentially exposed populations. Sections E.3.3 and E.3.4 present the results of this analysis for Operable Unit 1 in the form of conceptual site models for two different conditions.

The two conditions evaluated in this report are the current and future source terms with various land use patterns. These are described in detail in Sections E.3.3.1 and E.3.3.2, and are summarized as follows:

- Current Source Term
 - With current access restrictions
 - Without current access restrictions

- Future Source Term
 - Without current access restrictions, no development
 - Without current access restrictions, with development (farm residence)

Exposure magnitude, frequency, and duration are then quantified for each identified pathway and receptor. Section E.3.5 presents the determination of exposure point concentrations, and Section E.3.6 presents information on the methods used to quantify exposure for various pathways. As required by EPA, the exposure assessment is performed assuming both current and potential future uses of the site.

E.3.1 DEVIATIONS FROM THE RISK ASSESSMENT WORK PLAN ADDENDUM

This section presents Operable Unit 1-specific deviations from the Risk Assessment Work Plan Addendum (DOE 1992a), which are relevant to the exposure assessments. These variations are presented in a series of brief summaries with the rationale for each deviation. Additional details are provided in the appropriate sections of the exposure assessment. Deviations generally applicable to the Operable Unit 1 risk assessment are presented in Section E.1.0. Exposure assessment-specific deviations are presented in this section.

E.3.1.1 Exposure Scenarios and Receptors

No trespassing child is evaluated for Operable Unit 1 under current land use scenarios with existing access controls. Unlike several other operable units at the Fernald Environmental Management Project (FEMP), Operable Unit 1 is not only surrounded by the property fence, but by a second internal security fence as well. The fences, in combination with active security patrols, make it highly unlikely that a trespassing child could be exposed to the soil and/or waste pit contents under current land use conditions with active access controls.

Another receptor presented in the Work Plan Addendum that is not addressed in this exposure assessment is the on-property building user. Under current land use conditions, no buildings exist within the Operable Unit 1 boundaries.

E.3.1.2 Exposure Input Parameters

Several exposure input parameters were modified from those used in the Risk Assessment Work Plan Addendum (DOE 1992a), based on either the acquisition of more representative values and/or U.S. Environmental Protection Agency, Region V guidance. Specifically, revised soil ingestion rates for the resident farmer receptor were used in this risk assessment, as well as in the risk assessment conducted for Operable Unit 4. Derivation of this parameter is contained in Section E.3.5.6.5. Various dermal exposure parameters were also modified to incorporate EPA's dermal guidance documents (EPA 1992e). These deviations are discussed in Section E.3.5.6.9.

October 12, 1993

4787

E.3.1.3 Exposure Estimation and Methodologies

In response to EPA comments received on the Risk Assessment Work Plan Addendum, an alternate inhalation model for showering exposure was used in this risk assessment. EPA indicated that a model by Andelman (EPA 1991f) was the preferred model for indoor inhalation of chemicals volatilized, so this model was incorporated in this document (as described in Section E.3.5.2.2).

EPA Region V made additional comments on the Work Plan regarding dermal exposures. This risk assessment incorporates the latest EPA dermal guidance (see Section E.3.5.2.3 for further discussion).

Publication of new slope factors for radionuclides also resulted in a change in the way direct radiation exposures are calculated from that described in the Risk Assessment Work Plan Addendum (see Section E.3.5.1.3).

E.3.2 CHARACTERIZATION OF EXPOSURE SETTING

The Operable Unit 1 Study Area includes part of the FEMP and its surrounding environment. The following is a summary description of Operable Unit 1 Study Area characteristics that may be affected by proposed remedial activities at the FEMP or that may have a bearing on the study. More detailed descriptions of the local geography, surface topography, demographics, geology and hydrogeology, and ecology are presented in Section 3.0 of the Operable Unit 1 RI Report.

E.3.2.1 Climate and Meteorology

Information on the local climate was gathered from two primary sources — an on-property meteorological system installed at the FEMP in 1986 and the National Weather Service Office at the Greater Cincinnati Northern Kentucky International Airport. The FEMP meteorological station was installed in 1986 to collect site-specific data for wind speed and direction, ambient air temperature, lapse rate, dew point, temperature, relative humidity, barometric pressure, and precipitation.

The regional climate is defined as continental, with temperatures ranging from a monthly average of 29.2°F in January to 75.7°F in July. The highest temperature recorded from 1960 through 1989 was 103°F in July 1988, and the lowest was -25°F in January 1977. The average number of days per year with a minimum temperature of 32°F or less is 109 days, and the average number of days per year with a maximum temperature of 90°F or greater is 20 days. Yearly frost depth ranges from 30 to 36 inches.

The average annual precipitation for the Cincinnati area for the period of 1960 through 1989 was 40.56 inches and ranged from 27.99 inches in 1963 to 52.76 inches in 1979. The highest precipitation occurs during the spring and early summer; precipitation is typically lowest in late summer and fall. The average annual snowfall for the 1960 to 1989 period was 23.5 inches, with the heaviest snowfall in January. The total rainfall from January 1991 to January 1992 was 43.08 inches with the heaviest

rainfall at 6.2 inches in November 1991. The total snowfall from January 1991 to January 1992 was 12.9 inches, with the heaviest snowfall at 4.3 inches in January 1992.

A study by IT Corporation (IT 1986) indicates that National Oceanic and Atmospheric Administration (NOAA) wind flow data from the airport at Cincinnati were sufficiently representative of local conditions to serve as a database for the years prior to the installation of the on-property meteorological system. The FEMP meteorological station data indicates that two major terrain features, the Great Miami River Valley and the ridges surrounding the site, affect the wind patterns.

Figure E.3-1 shows the wind pattern recorded from a 10-meter tower at the FEMP in 1992. Prevailing winds are from the southwest and west-southwest. Section 5 of the Operable Unit 1 RI Report presents a more detailed frequency distribution summary of the numerical data from which the FEMP wind rose was generated.

E.3.2.2 Topography and Surface Hydrology

Operable Unit 1 is located above the floodplain of the Great Miami River drainage basin. It rests on a relatively level plain at about 580 feet above MSL. Drainage from Operable Unit 1 is currently regulated by engineering controls. These controls are assumed to fail sometime in the future, allowing the study area's topography to determine the flow of surface water. Surface water drainage of Operable Unit 1 historically flowed from east to west into Paddy's Run Creek (Paddy's Run). Paddy's Run, an intermittent tributary of the Great Miami River that runs along the western boundary of Operable Unit 1 lies between the waste storage area and the western property boundary of the FEMP.

Paddy's Run originates north of the FEMP, flows southward along the western boundary of the facility, and enters the Great Miami River approximately 1.5 miles south of the southwest corner of the FEMP property at river mile 19.5. The stream is about 8.8 miles long and drains an area of approximately 15.8 square miles. Paddy's Run is a steep-sided intermittent stream and its banks erode severely during high flow periods. This drainage has cut six feet or more through the silty clay near surface deposits upon which the facility is built. In 1961 and 1962, the course of the stream was altered to prevent it from eroding into the Operable Unit 1 Study Area (WEMCO 1987).

As stated previously, stream flow in Paddy's Run is intermittent, occurring only during periods of high precipitation. The stream is ungauged and peak flows occurring during storm events have not been measured. Typical flows for the January through May period range from 0.2 to 4.0 cubic feet/second (ft^3/s), based on best engineering judgment.

E.3.2.3 Soil and Geology

Soils in the region of the FEMP were formed from materials deposited by the Wisconsin and Illinoian glaciers. These parent materials consist mainly of glacial till, but also include sand, gravel, glacial-lake clays, and silt clays.

The major soils in the Operable Unit 1 Study Area are Fincastle silt loams, which also cover large areas west of the FEMP. These soils are light colored, medium acidic, and moderately high in productivity when properly managed. Moisture-supplying capacity is moderate, as are fertility and organic content. The Fincastle series consists of deep, nearly level, somewhat poorly drained soils on broad flatlands. Permeability is low and the available water capacity is high. In areas where these soils are predominant, artificial drainage is required for moderate crop productivity.

There is also a considerable amount of fill present in the waste storage area. This fill material has been placed in the berms around the waste pits.

E.3.2.4 Groundwater

The FEMP overlies a 2- to 3-mile-wide buried Pleistocene Valley known as the New Haven Trough. This valley was formed by the ancestral Ohio River during the Pleistocene and subsequently filled with glacial outwash materials that were in turn covered by glacial overburden. The outwash deposits in this buried valley under the FEMP are a part of the Great Miami Aquifer, which is a widely distributed buried valley aquifer. The valley fill aquifer system serves as a major source of domestic, municipal, and industrial water in the southwestern Ohio area.

The distribution of the overburden materials beneath the Operable Unit 1 Study Area are discussed in detail in Section 3.0 of the Operable Unit 1 RI Report. Much of the material within 10 feet of the ground surface has been reworked by FEMP activities and is no longer considered native material. The thickness of the glacial material beneath the Operable Unit 1 Study Area before waste pit construction ranged from 0 feet along Paddy's Run to over 40 feet at monitoring well 2027. The glacial overburden present beneath Operable Unit 1 is composed of primarily gray and brown clays and silts and represent Wisconsinan age glacial material. Sand and gravel stringers and beds found within the glacial overburden are undifferentiated glaciofluvial outwash deposits. Within the glacial overburden, beds and stringers of fine sand to coarse gravels are present. The more coarse-grained sediment at some locations in the waste storage area is continuous and can be correlated between two or more nearby wells. Several sand and gravel interbeds are present in the vicinity of Waste Pits 4 and 5, and may be hydraulically connected. Another sand and gravel interbed is observed in the vicinity of monitoring wells 1019, 1076, and 1021.

There is approximately 20 feet of unsaturated sand and gravel between the glacial overburden and the Great Miami Aquifer. Groundwater present in the sand and gravel interbeds is considered perched

because it is present in the glacial overburden above the Great Miami Aquifer. Depth to the perched water is approximately 5 feet below the bottom of the waste pits. [Groundwater elevations within Operable Unit 1 tend to be highest in the vicinity of Waste Pits 4 and 6.] There is a relatively low perched water gradient across most of the waste storage area, before water levels drop off sharply toward Paddy's Run. The perched groundwater table follows the general topography of the waste storage area and implies flow through the overburden from northeast to southwest.

Based on water level data, it has been observed that perched groundwater zones (sand and gravel interbeds) may be laterally continuous and interconnected. Perched groundwater present in the overburden is stored in the fine-grain material, clay and silt, matrices. During precipitation events, if sufficient surface water infiltrates into the subsurface, the unsaturated fine-grained material will become saturated and release water from storage. The released groundwater will then flow into the more permeable zones of sand and gravel interbeds, fractures and joints in the till, or downward to the Great Miami Aquifer. It has recently been postulated that perched groundwater might also be released to Paddy's Run via surface seeps.

Groundwater flow in the glacial overburden varies from saturated to partially saturated to unsaturated flow in the waste storage area. Saturated groundwater flow is generally observed from late winter to late spring, when precipitation events are common and the fine-grained material present in the overburden is saturated. When the fine-grained material is saturated, groundwater is present in the more coarse-grained sand and gravel interbeds as well as the joints and fractures observed in the unstratified till. Partially saturated and unsaturated flows are observed during drier periods of the year, when the finer-grained materials (silt and clay) become unsaturated and water is no longer present in the more coarse interbeds (sand and gravel) and clay/fractures. Saturated flow conditions occur in the Great Miami Aquifer.

E.3.2.5 Vegetation and Wildlife

Ecological communities on the FEMP consist of grazed and ungrazed pastures, two pine plantations, deciduous woodlands, and riparian woodlands. A total of 47 species of trees and shrubs, 190 species of herbaceous plants, 20 mammal species, 98 bird species, 10 species of amphibians and reptiles, 21 species of fish, 47 families of benthic macroinvertebrates, and 132 families of terrestrial invertebrates inhabit the FEMP.

Typical grasses found on the FEMP are red fescue, Kentucky bluegrass, timothy, and red top. Herbs include teasel, red and white clovers, and goldenrod. The dominant tree species in the pine plantations are white and Austrian pine, with Norway spruce occurring occasionally. Common trees in the deciduous woodlands are white ash, American elm, shagbark hickory, and slippery elm. Dominant tree species in the riparian woodlands are eastern cottonwood, hackberry, American elm, and box elder. Mammal species observed on the FEMP include white-tailed deer, coyote, red fox, opossum,

raccoon, groundhog, eastern cottontail, fox squirrel, and several species of bats. Common small mammals are the white-footed mouse, short-tailed shrew, meadow vole, meadow jumping mouse, and eastern chipmunk. The most common birds breeding on site include the mourning dove, American robin, blue jay, American crow, American goldfinch, northern bobwhite, and common grackle. Species occurring in the greatest density are the goldfinch, song sparrow, and robin. Raptor species observed on site are the northern harrier, red-shouldered hawk, Cooper's hawk, red-tailed hawk, and American kestrel. The eastern screech owl and great horned owl are also common. Amphibians and reptiles that occur on the FEMP include the American toad, spring peeper, eastern box turtle, and snapping turtle. Several species of snakes also occur on site, including the eastern garter snake, Butler's garter snake, black rat snake, northern water snake, and the queen snake. Approximately 130 insect families from 15 orders are represented in FEMP habitats. Leaf hoppers are abundant in all habitats, although less abundant groups include short-horned grasshoppers, leaf beetles, springtails, fruit flies, dark-winged fungus gnats, ants, bees, and wasps.

The results of a survey indicated that wetlands at the FEMP are limited to a forested wetland of approximately 50 acres in the northern portion of the facility and emergent wetlands associated with tributaries and drainage ditches that feed into Paddy's Run (DOE 1992d). The stretch of Paddy's Run adjacent to Operable Unit 1 is characterized as an unvegetated stream channel incised into surrounding uplands. Unvegetated stream channels do not meet the wetland criteria and would be classified as "other waters of the United States." As such, they would not be protected by wetlands regulations, but remedial actions affecting them would still be subject to the substantive requirements of the Clean Water Act.

E.3.2.6 Demography

The FEMP is located approximately 18 miles northwest of Cincinnati, and is the focal point of a regional market encompassing the following eight counties: Butler, Clermont, Hamilton, and Warren counties in Ohio; Boone, Campbell, and Kenton counties in Kentucky; and Dearborn County, Indiana. These eight counties also define the Cincinnati Consolidated Metropolitan Statistical Area. Population within the eight-county metropolitan area was more than 1.7 million in 1990, and within a 5-mile radius of the FEMP there was an estimated 22,927 residents. Labor force in the multi-county area was more than 920,000 with unemployment at approximately 5.5 percent in December of 1991.

The cities of Hamilton and Fairfield are located six and eight miles northeast of the FEMP, respectively. Scattered residences and several villages, including Fernald, New Baltimore, Ross, New Haven, and Shandon, are located near the FEMP. Concentrations of residential units are situated (1) immediately north of the FEMP; (2) in Ross, and (3) directly east in a trailer park at the intersection of Willey Road and State Route 128. Other residences are scattered around the area, generally associated with farmsteads.

The nearest resident is located within 0.75 mile from the center of the facility. The nearest residences to the western FEMP property boundary (the boundary along the eastern side of Paddy's Run Road) are located along the western side of Paddy's Run Road. A dairy farm is located on Willey Road just outside the southeast corner of the FEMP property boundary (leased grazing areas include areas inside the FEMP property boundary). Several residences are located off Paddy's Run Road approximately 0.5 mile south of the FEMP property boundary and along New Haven Road approximately 1 mile south of the FEMP property boundary. These residences are in the vicinity of the South Plume, a portion of the Great Miami Aquifer that contains a plume of uranium contamination that extends south of the FEMP property boundary approximately 0.75 mile.

E.3.2.7 Land Use

The land adjacent to the FEMP is primarily devoted to open land use such as agriculture and recreation. Agricultural activities include dairy, beef, corn, and soy bean production (refer to Figure E.1-3). Commercial activity is generally restricted to the village of Venice (Ross), approximately 3 miles northeast of the facility, and along State Route 128 just south of Fernald. More than 400 acres of the open land on the FEMP are currently being leased to local dairymen for livestock grazing. Pine plantations are located northeast and southwest of the former Production Area. A considerable amount of the land within the boundaries of the FEMP are designated by the U.S. Department of Agriculture as prime agricultural land (USDA 1980, 1982).

Several industries, including Delta Steel, Albright & Wilson Chemical Company, Ruetgers-Nease Chemical Company, two commercial gravel operations, and a cement plant, are located south of the FEMP. Industrial use is concentrated along Paddy's Run Road, in the village of Fernald, and in a small industrial park on State Route 128 between Willey Road and New Haven Road.

The Miami Whitewater Forest, a Hamilton County park is located within five miles of the FEMP. The former Camp Ross Trails, owned by the Great Rivers Girl Scout Council, is located approximately 1 mile northeast of the FEMP.

A security fence surrounds the entire FEMP property, and a second line of fences surrounds several internal areas, including Operable Unit 1. These fences are regularly patrolled by a full-time security force. These active (security patrols) and passive (fences) access controls are currently in place at the FEMP. No hunting or fishing is allowed on Operable Unit 1.

E.3.2.8 Future Land Use

It is difficult to develop reasonable future land use scenarios at government facilities. Because many current remedial alternatives include in situ, or continuing on-site waste management, a reasonable future land use scenario would be that the government retains control of the property and restricts access in perpetuity in order to prevent future exposures. This scenario is addressed in the Operable

Unit 1 Baseline Risk Assessment by evaluating risks to the off-property farmer from future Operable
Unit 1 sources.

In addition, because of the uncertainty associated with future sociopolitical activities, it is prudent to evaluate the effect of future potential exposures assuming that the government loses control of the land. For the purposes of the risk assessment, "future land use" refers to the unrestricted use of the property. Because some of the land surrounding the facility is currently used for farming, it is reasonable to assume that the FEMP property could be used as farm land at some time in the future. Scenarios that assume loss of institutional controls provide the basis for determining the level of cleanup necessary in order to eliminate the need for ongoing institutional controls.

E.3.2.9 Critical Subpopulations

According to the Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A) (EPA 1989a), a baseline risk assessment must identify subpopulations of potential concern that could be at increased risk from radionuclide or chemical exposure from increased sensitivity, behavior patterns, and/or current or past exposures from other sources. These populations include infants and children, the elderly, pregnant and nursing women, individuals with chronic illnesses, and individuals previously exposed to chemicals or radionuclides during occupational activities or by residing in industrial areas. The current subpopulations of potential concern within five miles of the FEMP are identified below and are listed by the categories suggested by EPA (1989a). The information presented on sensitive subpopulations covers the area within five miles of the FEMP and covers the area within three to four miles of the leading edge of the South Plume. Within this distance from the South Plume the population difference based on 1990 census data is negligible and the descriptions of potential sensitive subpopulations are essentially the same. Subpopulations of potential concern are identified using 1990 census data.

- Schools — Northwest, Ross, and Southwest school districts provide public education from kindergarten through high school for children living within 5 miles of the FEMP. The 1989-90 total enrollment in the six schools from these districts FEMP was 3,316. No schools are located within 1 mile of the FEMP.
- Daycare Centers — No daycare facilities are located within 1 mile of the FEMP. Two daycare centers operate within the study area: 1) Ross County Day Nursery, with an average enrollment of 126 students per day and a total weekly enrollment of 180, is located north of the intersection of State Route 128 and U.S. 27 about two and one-half miles northeast of the center of the FEMP, and 2) Venice Presbyterian Pre-School, with an average daily enrollment of 30 and a total weekly enrollment of 110, is located in the village of Venice (Ross) approximately 2 miles northeast of the center of the FEMP.
- Hospitals, Nursing Homes, and Retirement Communities — No care facilities of these types operate within 5 miles of the FEMP.

- Residential Areas with Children — In 1988, approximately 58 adults and 29 children resided within 1 mile of the FEMP. Most of the residences within five miles of the FEMP are scattered and reflect the agricultural setting of the area. Population concentrations include Ross, Harrison, Shandon, Fernald, New Haven, New Baltimore, and one large trailer park. An estimated 8,140 children lived within 5 miles of the center of the FEMP in 1988.
- Commercial and Recreational Fisheries — No commercial fisheries operate within five miles of the center of the FEMP. Recreational fishing occurs on Whitewater Lake of the Miami Whitewater Forest Park. This heavily-stocked lake lies completely within five miles of the FEMP. The Great Miami River supports no commercial fisheries in the vicinity of the FEMP, but recreational fishing occurs downstream from the FEMP. The Ohio Department of Health issued a fishing advisory for PCBs in bottom-feeding fish in 1989 based on data collected by Ohio Environmental Protection Agency (OEPA).
- Major Industries Using Chemicals — No industrial facilities are located within one mile of the center of the FEMP. Two companies located within two miles of the FEMP center, Ruetgers-Nease Chemical Company and Albright and Wilson, store and handle chemicals. Collectively known as the Paddy's Run Road Site, these facilities are classified as Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites, are listed on the Comprehensive Environmental Response Compensation and Liability Information System (CERCLIS), and are undergoing a state-led Remedial Investigation/Feasibility Study (RI/FS). Proctor & Gamble has a research facility approximately two miles east of the FEMP, which is listed on CERCLIS and has undergone a Screening Site Inspection by U.S. Environmental Protection Agency (EPA). Employees at these facilities are only considered a sensitive subpopulation if they reside within five miles of the FEMP.

Critical subpopulation, per se, are not evaluated quantitatively in the Operable Unit 1 baseline risk assessment. This demographic information is used to select receptors for the exposure assessments which provide an upperbound estimate on exposures to these sensitive populations. For example, exposures to children in off-property schools or day care facilities are not quantitatively evaluated. However, after careful consideration of the circumstances surrounding these children, it is concluded that exposures to these receptors will be much lower than exposures to the on-property resident child because of his low body weight and the accessibility to higher concentrations of constituents.

E.3.3 CONCEPTUAL SITE MODEL

Conceptual site models facilitate consistent and comprehensive evaluations of the risks to human health by creating a framework for identifying the paths by which human health may be impacted by contaminants found at Operable Unit 1. The conceptual site models depict the relationships between six elements necessary to construct a complete exposure pathway, as follows:

- Sources and potential CPCs
- Release mechanisms

0461

- Transport pathways
- Exposure mechanisms and exposure routes
- Receptors

Two conceptual site models were developed for Operable Unit 1 to provide the basis for identifying the potential risks to human health in the Baseline Risk Assessment. One conceptual site model considers the potential risks to human health from the current configuration of source terms and receptors (current conditions) and is discussed in Section E.3.3.1. The second model considers potential risks from a hypothetical future configuration of source terms and receptors (future conditions) and is discussed in Section E.3.3.2.

The conceptual models developed for this assessment begin by considering the source terms assumed to be available, either currently or in the future. These source terms include buried wastes, exposed wastes, contaminated surface soil, or contaminated water in the open waste pits. Contaminants are released from these sources by mechanisms such as leaching to groundwater, erosion, volatilization, and overflow. Once released from the source(s), contaminants are transported in media such as air, groundwater, surface water, and sediment. Receptors may be exposed either directly or indirectly to contaminants in these media via a variety of mechanisms. The exposure mechanisms considered include using contaminated water for domestic and agricultural uses, raising plants and animals on contaminated soil, direct exposure to radiation, etc. These exposure mechanisms generally act along one or more exposure routes, such as ingestion or inhalation.

The conceptual site models also indicate which exposure routes are carried through the quantitative risk assessment for each receptor under three land use definitions: current land use with access controls; current land use without access controls; and future land use. An objective of the development of the conceptual site model and analysis of exposure routes and receptors is to focus on those pathways and sources that contribute the most to the potential impacts on human health, and to provide the rationale for screening out other exposure pathways that are likely to pose minor risks.

E.3.3.1 Conceptual Site Model - Current Source Term

Operations within the FEMP production area generated large quantities of liquid and solid wastes, and between 1952 and 1985, much of these wastes were disposed of in the waste storage area. The radiological and chemical wastes in Operable Unit 1 represent a potential source of environmental contamination.

Operable Unit 1 is divided into eight waste pits and the surrounding soils. The eight waste pits are identified as Waste Pits 1 through 6, the Burn Waste Pit, and the Clearwell. At present, Waste Pits 5 and 6 and the Clearwell are filled with water, and the other waste pits are covered with soil caps of varying thicknesses. These waste pits represent the primary sources of concern in Operable Unit 1. Detailed descriptions of each waste pit, including its use and characteristics, are provided in the body

of the RI Report. Subsurface soil outside the waste pits represents a minor source term in comparison to the wastes buried in the waste pits, thus, are not evaluated in this assessment.

In addition to the waste pits, surface soil both inside and outside of the waste pit boundaries has measurable levels of contamination available for transport via air and surface water erosion. These soils can also contribute to receptor exposures by direct contact, food chain, ingestion, and direct radiation pathways, and are therefore considered in the risk assessment.

The current source term configuration used in this assessment reflects the physical state of the operable unit as it exists today. Land uses considered are current land use with or without access controls. The current conceptual site model, depicted in Figure E.3-2, is based on the following assumptions:

- Waste Pits 1, 2, and 3, and the Burn Pit are covered with soil
- Waste Pit 4 is covered with a RCRA cap (polyethylene over 4 feet of compacted clay)
- Waste Pits 5 and 6 and the Clearwell are filled with water
- Infiltration through the site does not change
- Surface water runoff is collected by the existing drainage system (Removal Action 2)
- Vegetative cover remains unchanged
- The effects of radiological and chemical decay of the source are assumed to be minimal

The conceptual site model does not consider existing contamination in groundwater or off-site sediment, as these media will be addressed in the Operable Unit 5 risk assessment. Only soil, surface water, and waste pit material from within the boundaries of Operable Unit 1 are considered in this assessment, as are groundwater, surface water, and sediment contamination that has as its source the media within the boundaries of Operable Unit 1.

E.3.3.1.1 Release Mechanisms

Both solid and liquid source materials exist at Operable Unit 1. The release mechanisms for these sources are discussed separately. Sources containing solid materials are Waste Pits 1, 2, 3, and 4, the Burn Waste Pit, and remaining soil outside the waste pits themselves. Given the assumptions of the current source term model, release mechanisms acting on solid media are limited. Removal of exposed solid source materials can occur via wind erosion. Another mechanism releasing contaminants from solid wastes involves the emission of gases from the solid matrix as a result of either volatilization or radon generation. Releases via surface water runoff are not addressed in the current scenario, given the presence and assumed continued operation of the runoff control system. A secondary release mechanism from solid media is the uptake of contaminants in soil by plant roots and their subsequent ingestion (along with soil) by grazing cows should access controls be discontinued.

Releases from liquid source areas (Waste Pits 5 and 6 and the Clearwell) are not addressed in the current source term conceptual site model because the model is based on the assumption that the

existing runoff collection system remains in operation. One secondary release mechanism considered, however, is the ingestion by cows of surface water from the waste pits or Clearwell should access controls be discontinued.

E.3.3.1.2 Transport/Exposure Media

Once released to the environment, CPCs can enter several media which then convey the contaminants to the vicinity of a receptor. Media transporting contamination from a source are called transport media in this assessment. Once contamination has been transported to the vicinity of a receptor, the receptor can be exposed during contact with one or more contaminated media. These media, called exposure media in this assessment, may or may not be the same media that originally transported the contamination to that location. The following subsections describe the transport and exposure media considered in this assessment.

Air

Air can contain suspended particulates and/or gaseous contaminants that originate at Operable Unit 1. Bulk movement of air can then convey the particulates and gases to a receptor location. Thus air can serve as both a transport medium and an exposure medium.

Surface Water

Surface water can contain contaminants in either dissolved or suspended form. Standing water is currently found in Waste Pits 5 and 6 and the Clearwell. This surface water can serve as an exposure medium.

Under the Consent Agreement, EPA required an interim removal action to collect, transfer, and treat surface water runoff from the waste storage area prior to its discharge to the Great Miami River. As part of this removal action, a storm water runoff control system was created for the waste storage area. Operation of the runoff control system is considered as part of the baseline conditions for the Operable Unit 1 Baseline Risk Assessment for the current, but not the future, exposure scenarios.

The existing contamination in surface water bodies such as Paddy's Run, the outfall ditch, and the Great Miami River is considered within the scope of Operable Unit 5; however, the future impact of sources within Operable Unit 1 on Paddy's Run and the Great Miami River via surface water erosion is included in the scope of the conceptual model for Operable Unit 1. Among the source terms are the surface soil within the Operable Unit 1 boundaries and the waste from the waste pits after their soil cover erodes away.

Grazing Livestock and Food Crops

Domestically raised food can be contaminated in a variety of ways. The roots of vegetables and fruit can draw contaminants from the surrounding soil and pass them along to edible portions of the plant.

Under the current source term conditions, contaminants can also be deposited on plant surfaces by aerial deposition of dust. Animal products, such as beef and milk, can become contaminated when animals are fed contaminated food or water, or are grazed in areas containing contaminated soil. Since plants and animals can be moved from the source area to a receptor, they are considered both a transport medium and an exposure medium in this assessment.

E.3.3.1.3 Exposure Mechanisms and Exposure Routes

A receptor can come into contact with contaminants in a variety of ways, which are generally the result of interactions between a receptor's behavior or lifestyle and exposure medium. This assessment defines an exposure mechanism as a stylized description of the behavior that brings a receptor into contact with a contaminated medium.

Exposure routes are divided into two types — internal exposure and external exposure. Internal exposures occur when contaminants are introduced directly into the human body. These are inhalation, ingestion, and absorption across dermal surfaces. External exposures can occur independently of any physical contact with a medium. Such exposures are only considered for radionuclides and result from irradiation of an individual by penetrating radiation from a radioactive source.

Immersion in Air

This pathway is based on the scenario that a receptor is immersed in air that contains suspended particulates, gases such as radon, and volatile organic vapors originating in soil or waste. Subsequent exposures can occur either via inhalation or penetrating radiation.

Aerial Deposition onto Soil and Plants

Airborne particulates tend to settle out of the air over time. When these particulates settle out over farmland, they can be deposited on the surfaces of plants or onto surface soil. This contamination can remain affixed to the outside of the plant or fall to the ground, where some will be absorbed through the plant's roots. These plants are then used directly as food, or are fed to livestock. Exposures can occur either through the direct (but incidental) ingestion of or dermal contact with contaminated soil; via ingestion of fruit, vegetables, meat, or dairy products; or via penetrating radiation.

Direct Contact

Receptors may come into direct contact with contaminated soil or waste pit material. During the receptor's period of contact, the individual may be exposed via inadvertent ingestion of a small amount of soil or waste or dermal absorption of certain contaminants.

Harvesting Crops and Livestock

This exposure mechanism is based on harvesting contaminated food crops and/or animal products for human consumption. Food crops grown for human or animal consumption may become contaminated in several ways — via irrigation with contaminated water or via uptake from contaminated soil. Contaminants in animal feed are subsequently bioaccumulated into edible tissue or milk, which can be ingested by local or distant residents.

Using Surface Water as Stock Water

If access controls are discontinued, it would be possible for grazing livestock to enter the operable unit and drink from the standing water in Waste Pits 5 and 6 or the Clearwell. Milk from dairy cows or beef from cattle could be ingested by either local or distant residents.

Recreational Use of Surface Water in Waste Pits

If access controls are discontinued and local memory of the former uses of the property is lost, it is possible that local children could use the Clearwell for recreational purposes such as catching frogs or swimming. However, it should be noted that Waste Pits 5 and 6 are full of debris, and the water in the Clearwell is stagnant and laden with algae, therefore none of the water bodies is considered to be an attractive swimming location. Children could, however, be exposed accidentally via ingestion, dermal contact, inhalation of volatiles, and/or penetrating radiation.

E.3.3.1.4 Receptors

The receptors evaluated in the Operable Unit 1 risk assessment under the current source term configuration were selected by analyzing the interaction of current land use practices (Section E.3.2.7), the source term (Section E.3.3.1), and the presence or absence of access controls. The impacts of access controls on receptor selection, and the receptors who might reasonably be exposed using the current conceptual site model, are discussed below.

Receptors Considered With Access Controls

A security fence currently surrounds the entire FEMP property, and a second line of fences surrounds several internal areas, including Operable Unit 1. These fences are regularly patrolled by a full-time security force. These active (security patrols) and passive (fences) access controls are currently in place at the FEMP. During the past 40 years, these controls have proven successful in restricting unauthorized site access to intruders. No hunting or fishing is allowed in Operable Unit 1.

Thus when access controls are in place, the only exposure points that are regularly accessible to receptors are off-property locations. Because of the current nature and extent of contamination and the environmental transport dynamics of the operable unit, off-property locations were limited to areas immediately contiguous to the site. These locations are thought to present the reasonable maximum exposure (RME) for this scenario.

4787

There is also a potential for an occasional site visitor to be exposed to contaminated media at Operable Unit 1. These exposures, however, are considered to be intermittent in nature.

The receptors selected under the current land use/access controls configuration are based on the assumption that the federal government maintains the site, and no capital improvements are made. The following receptors are considered in the Operable Unit 1 risk assessment under the current source term configuration:

- Off-Property RME Farmer — This hypothetical receptor lives immediately adjacent to the FEMP boundary and is affected only by those contaminants that are subject to transport through environmental media. At the present time, there are no homes in this area of concern just west of the property boundary.
- Visitor — This hypothetical receptor is an adult aged 19 through 43 who regularly visits the Operable Unit 1 area on business over a 25-year period of time. Exposures may occur through direct contact with environmental media once inside the fence. Soil ingestion and dermal contact are not considered for this receptor, as the Risk Assessment Work Plan Addendum (DOE 1992a) as stated that this receptor would not disturb the soil in any way.

Under the current source term configuration, no other receptors are identified.

Receptors Considered Without Access Controls

This group of land users reflects the possibility that the current governmental/industrial use of the property continues but with less perimeter security. Maintenance on the site is assumed to cease, but no capital improvements are made. The following are receptors who are considered to be reasonably exposed to the current levels of contamination:

- Off-Property RME Farmer — As described above.
- Trespassing Child — This hypothetical receptor is an older child aged 6 to 17. Under the current land use scenario where access controls are eliminated, this receptor is assumed to play in the Operable Unit 1 area, and can therefore come into direct contact with on-site, contaminated media.
- Off-Property User of Meat and Milk — This receptor is an off-property resident who uses animal products from livestock grazed and watered on Operable Unit 1. It is described in the Risk Assessment Work Plan Addendum (DOE 1992a) as the on-property grazing receptor. The purpose of this receptor is to evaluate exposures to the subpopulation of people who might use beef and dairy products from animals exposed to on-property media.

E.3.3.1.5 Complete Exposure Pathways

An exposure pathway is complete if it is determined that there is 1) a source or a release of chemicals from a source; 2) an exposure point where contact can occur, and 3) an exposure route by which contaminants are taken into the body. This section summarizes the complete exposure pathways that are quantitatively evaluated in the risk assessment and provides the rationale for those pathways that are not. Table E.3-1 presents a summary matrix of the complete exposure pathways and receptors from the conceptual site model presented in Figure E.3-2. Risks will be calculated for each receptor under multiple exposure pathways, and the risks will then be summed to provide a total risk for each receptor.

E.3.3.1.6 Exposures Under Current Land Use with Access Controls

Under current conditions, as considered under current land use with active access controls, only two receptors are evaluated.

The off-property RME farmer is the receptor who is considered to be the maximally exposed individual under the current land use/access control scenario. This receptor, based on the modeling described in Appendix D, is located about 500 meters southwest of the Burn Pit. The following exposures are considered quantitatively for this receptor:

- Inhalation of (off-property) ambient air containing radon, volatile organics, and respirable particulates PM-10 — Air concentrations are based on the modeling described in Appendix D. Volatile emissions from cloud immersion are not considered in this scenario, given their low concentrations in surface media, and penetrating radiation from cloud immersion is considered to be a minor exposure route for which there are no EPA-approved methods for calculation.
- Ingestion of vegetables and fruit affected by aerial deposition — Deposition of radionuclides and other contaminants adsorbed to suspended particulates on surface soil in which plants are grown or onto the vegetation itself results in absorption by the plants. The contaminants are derived from on-site surface soil and exposed waste pit material; off-property deposition information is derived via modeling of the suspended particulates. Other potential exposures resulting from the aerial deposition mechanism were considered to be minor routes of exposure (incidental ingestion of soil, dermal contact with soil, and penetrating radiation).
- Ingestion of meat and milk affected by aerial disposition - Deposition of particulates could also indirectly affect meat and milk consumed by this receptor. Particulates deposited on soil and vegetation can be ingested by grazing cows, and contaminants can subsequently be biotransferred to meat and milk.

Several other exposure routes were included in the conceptual site model but were not quantified in the risk assessment. Ingestion of beef and dairy products from cows grazed or watered on property was not considered because under current land use and access conditions, no cows get inside the inner security fence. Direct contact with contaminated surface soil or waste pit material is not considered

because this receptor lives off-property and is not likely to come on property. Finally, again because the receptor is not assumed to come on the property, accidental exposures to surface water in the Clearwell were not considered.

The other receptor evaluated under current land use and access controls conditions is identified as a site visitor. The definition of this receptor is based on the fact that this person lives remote from the site, and only experiences exposures when on property. The exposures evaluated for this receptor are extremely conservative, as Operable Unit 1 has no on-going commercial or industrial activities. The following exposure routes are addressed for the visitor:

- Inhalation of air containing radon gas, volatile organics, and respirable particulates (PM-10) — Resuspension of exposed waste pit material and surface soils, as well as emission of radon gas, are considered for this receptor. Penetrating radiation from the air itself, which could possibly occur, is considered to be a minor exposure route.
- Proximal exposure to soil and waste pit material — Once inside the security fence, the site visitor could be exposed to contaminated surface soil and exposed waste pit material under current site conditions. However, visitors are not expected to disturb the soil and be exposed via ingestion or dermal contact, so only penetrating radiation exposures are considered.

This receptor is not assumed to ingest any plant or animal products grown on the property, nor is it considered likely that such a visitor would experience anything other than an accidental exposure to surface waters in the waste pits and Clearwell.

E.3.3.1.7 Exposures Under Current Land Use Without Access Controls

If the government should retain ownership of the property, yet decrease site security, the number of receptors potentially exposed to Operable Unit 1-related contamination increases, as do the number of exposure routes that come into play. Three receptors are considered under these conditions.

The first receptor considered is the off-property RME farmer. This receptor's exposures under this scenario are identical to those for current land use conditions with access controls. No additional exposure routes are considered.

The second receptor is a trespassing child. This receptor is exposed only via direct contact or via inhalation of volatile, gaseous, or particulate emissions. The potential exposure to surface water in the Clearwell is considered, but was not included in the final quantitative exposure assessment because the water in the Clearwell is not suitable for regular recreation such as swimming. The water contains heavy algal growth, and exposures would most likely be accidental. Based on exposure times and intake rates, these acute exposures were judged to be insignificant in the total risk experienced by this receptor.

The third receptor considered, if current land use should continue without access controls, is the off-property user of meat and milk from cows grazed on-property. This is a distinct pathway that could affect sensitive subpopulations living far from the FEMP. The following pathways are considered:

- Ingestion of meat and milk contaminated via root uptake — Without access controls, it is possible that cows could graze in the vicinity of Operable Unit 1. In this case, contaminants in soil could be taken up by plant roots either directly or via aerial deposition. These feed crops (and some attached soil) would be ingested by cows, and contamination could be passed on to the consumer via beef or milk.
- Ingestion of meat and milk contaminated via surface water ingestion — It is also possible, should access controls be discontinued, that cows could ingest water from the Clearwell or Waste Pits 5 and 6. Contamination in these waters could be passed on to consumers via beef or milk.

E.3.3.2 Conceptual Site Model - Future Source Term

The future source term configuration is purely hypothetical. It assumes that the operable unit becomes part of a homestead, and is developed by considering both the site's current configuration and the processes that would act on it if all maintenance activities were discontinued. The future conceptual site model, shown in Figure E.3-3, is based on the following assumptions:

- The cover material over Waste Pits 1 and 2, and the Burn Waste Pit remains intact.
- The Waste Pit 4 polyethylene cap degrades and the clay material is exposed.
- Waste Pits 5 and 6 are only half-filled with water, and the other half of the waste pits' surface areas consist of exposed waste pit material as a result of evaporation or infiltration.
- Sediments on the bottom of the Clearwell remain covered with water because of its depth and steep sides.
- The cover material over Waste Pit 3 settles and buried wastes are exposed.
- Waste Pits 1 and 2 are irrigated and used to grow crops and animal feed.
- Infiltration through the site is altered by the changes in the water levels in the waste pits, the degraded cover of Waste Pit 3, and the use of irrigation on Waste Pits 1 and 2.
- Excess surface water runoff flows to Paddy's Run.
- Vegetative cover is consistent with local agricultural practices and ecological succession.
- A house is placed on the most stable Waste Pit (Pit 4), and a well is drilled at the location producing the maximum risk.

The future scenario configuration is developed as described above for a number of reasons. Pits 5 and 6 are assumed to be half-filled with water and have exposed waste material because the current waste "topography" is uneven and higher on one end than the other. Therefore, if water were to evaporate or infiltrate waste could be exposed. Half the area was used as an example.

Sediments in the Clearwell are assumed to remain covered with water. The sides of this pit are steep, and removal of part of the water would not result in exposure of sediments on the bottom.

It was assumed that the cover over Pit 3 would settle because the pit material is semi-solid and therefore unstable. This instability is assumed to affect the integrity of the cover material, leading to settling and erosion of its exposed contents. In addition, because this pit is the largest in surface area and volume, exposing its contents is a conservative assumption.

The covers of Waste Pits 1, 2, and 4 and the Burn Pit were not assumed to erode in the future scenario. This assumption was made because the materials deposited within these waste pits consists primarily of solid (dry) wastes. Solid wastes are assumed to be more stable and less likely to settle and result in failure of the cover. Waste Pit 4 is covered with a RCRA cap (4-foot thick clay and polyethylene liner) that is assumed to significantly reduce or eliminate erosion of waste material. Waste Pits 1 and 2 and the Burn Pit are covered with soil and are assumed to be vegetated which significantly reduces erosion.

Of all the pits, Pit 4 is considered to be the most stable. In addition, the groundwater beneath Pit 4 is the most contaminated, therefore the installation of a well at this location was selected to be conservative. By default then, the home would also be constructed on this pit. However, the RCRA cap and high concentrations of contaminants in the pit material would retard grass growth, so topsoil was assumed to be emplaced after construction is complete.

Finally, since the resident farmer is being evaluated, the only area left for growing crops is Pits 1 and 2. Their adjacent location makes this a suitable area. It was assumed that the caps remain intact, otherwise, crop growth would be unlikely to occur.

As with the current source term model, the conceptual site model does not consider existing groundwater, surface water, and sediment contamination, which are within the scope of Operable Unit 5.

E.3.3.2.1 Release Mechanisms

Solid source areas are subject to additional release mechanisms from those considered for the current source term, as a result of the changed configuration that is assumed for these scenarios. In addition to the mechanisms that apply to the current source term models, the following mechanisms are considered:

- Chemicals in solid source areas are subject to leaching by infiltrating rainwater. Chemicals in solution may migrate beyond the physical boundaries of the source area.
- Exposed waste pit materials can be released via surface water erosion, if the runoff collection system is no longer in operation. Constituents in the sources can be dissolved and transported in either ionic or colloidal form.

Sources that primarily contain liquids include Waste Pits 5 and 6 and the Clearwell. Under the future source term definition, the liquids in these sources may leach through the bottoms or sides of the individual units and eventually reach the groundwater. The liquids can also be transported via surface water runoff if the waste pits overflow. Escaped liquids can then flow over the ground surface and enter local drainage features, where they can flow in conjunction with the surface water.

The source terms considered for the groundwater transport modeling are limited to those materials that leach from the waste material and cover material inside the waste pit boundaries. Subsurface soil material located outside the waste pits exhibit much lower contaminant concentrations, and therefore are not considered in the modeling (see Appendix D).

E.3.3.2.2 Transport/Exposure Media

Because different site conditions are considered for the future source term, additional transport and exposure media must be considered for this conceptual site model.

Surface Water

In addition to the standing water described for the current source term configuration, surface water plays another role at this operable unit. Under the Consent Agreement, EPA required an interim removal action to collect, transfer, and treat surface water runoff from the waste storage area prior to its discharge to the Great Miami River. As part of this removal action, a storm water runoff control system was created for the waste storage area. It is felt that these engineering controls are not permanent, therefore operation of the runoff control system is considered as part of the baseline conditions for the Operable Unit 1 Baseline Risk Assessment for the current, but not the future, exposure scenarios.

Without the existing runoff control system, surface water could flow over the ground surface and carry dissolved or suspended contaminants to the Great Miami River via Paddy's Run. Paddy's Run itself is not considered to be a reservoir of surface water because of its intermittent flow in this area. Therefore, surface water is considered to be both a transport medium and an exposure medium.

Groundwater

Groundwater can contain dissolved contaminants that have leached from the source areas. The principle source of potable water in the vicinity of the FEMP is the Great Miami Aquifer, which is located beneath most the FEMP and Operable Unit 1. The bulk flow of groundwater in this aquifer can convey contaminants to local and distant receptors. Thus groundwater can serve as both a transport medium and an exposure medium under this scenario.

Transport mechanisms to the groundwater can potentially contaminate the aquifer from source terms in Operable Unit 1. The source terms included in groundwater transport modeling are limited to leaching

from the waste material inside the waste pits. Leaching from the surface and subsurface soils (outside of the waste pits) in Operable Unit 1 is not included in the groundwater transport modeling because these sources exhibit far lower contaminant concentrations and quantities of contaminants than the waste pit wastes themselves.

The depositional characteristics and the hydrostratigraphic units present beneath Operable Unit 1 impart the following general contaminant transport characteristics to solutes migrating from the individual waste areas.

- Solute migration potential — The fractured nature of the weathered tills confer a high migration potential for solutes. Solute migration can also occur through the unweathered till, but at a much slower rate. Once the solute reaches the glacial outwash, the solute migration potential is high, based on the high hydraulic conductivity of the matrix.
- Aquifer intercommunication — The glacial environment limits the intercommunication between perched water-bearing zones. Communication between the upper water-bearing zones within the till and the Great Miami Aquifer is likely over an extended period of time. Communication between upper and lower zones within the Great Miami Aquifer will be extremely limited due the presence of 10- to 20-foot thick clay aquitard. Therefore, transverse (vertical) dispersion will be the only mechanism for contaminant migration between the upper and the lower zones.
- Adsorption/attenuation characteristics — The layers found within the glacial overburden generally have sufficient organic carbon content to cause retardation of organic constituents. The clay mineralogy would result in significant cation retardation for inorganic constituents. Given the till matrix, it is also unlikely that all of the available sites for adsorption would be used by solutes; therefore, it is unlikely that adsorption/attenuation breakthrough would occur. Adsorption/attenuation will occur at lower rates in the regional aquifer due to the lower organic carbon and clay content in the outwash.

Based upon the general hydrogeologic and contaminant transport characteristics, there is a potential pathway from the waste areas through the vadose zone to the regional aquifer. Given the high energy depositional characteristics of the glacial outwash, the pathway would extend from the aquifer-vadose interface to downgradient receptors.

Perched Water

Perched water is found in the vadose zone above lenses of less permeable soil. While the volume and quality of the perched water in the Operable Unit 1 area precludes its use as a consistent water supply, EPA Region V has requested that risks from drinking water be quantified for any perched water detected beneath the FEMP. Therefore, perched water is included as an exposure medium in the conceptual site model for the future source term configuration. Perched water can also serve as a transport medium for contaminants to reach the underlying Great Miami River.

Sediment

Sediment is created by the erosion of soil and/or waste material by flowing surface water. The future source term configuration is based on an assumption that the existing runoff control system is no longer in operation, and therefore that the impacts of eroded sediment on Paddy's Run and the Great Miami River are considered. Sediment is treated only as an exposure medium in this assessment because the bulk movement of surface water actually transports the sediment downstream.

Grazing Livestock and Food Crops

In addition to the transport/exposure media discussed for the current source term configuration, another aspect should be considered. Not only can food crops become contaminated via aerial deposition, they can also become contaminated via irrigation with contaminated groundwater or surface water (e.g., Great Miami River). This scenario is considered in the future source term evaluation.

E.3.3.2.3 Exposure Mechanisms and Exposure Routes

In addition to the routes of exposure addressed for the current source term configuration (air immersion, aerial deposition onto soil and plants, direct contact, harvesting crops and livestock, using surface water as stock water, and accidental exposure to surface water in the waste pits), several other routes of exposure must be considered for the future source term. These are addressed in the following paragraphs.

Using Water from Shallow Well for Drinking

Perched groundwater at Operable Unit 1 lacks the volume and water quality necessary for use as a consistent water supply, although it is possible that limited use could occur. EPA Region V has requested that exposures to perched water be addressed. Therefore, ingestion of water from a shallow well installed in the perched water zones beneath Operable Unit 1 is included in the risk assessment in only the future source term model. The water to be used is considered to be derived from leaching through soil and waste pit material.

Using Water from Aquifer for Drinking, Domestic, and Agricultural Purposes

Groundwater in the Great Miami Aquifer has historically been used as the water supply in the vicinity of the FEMP. This exposure mechanism entails using this water to supply a small farm for all uses (ingestion, showering, cooking, irrigation of food crops, irrigation of animal feed, and stock water). Multiple exposure routes are considered — ingestion, dermal contact, inhalation during showering, and ingestion of food that has been directly or indirectly contaminated. Penetrating radiation from contaminated water was qualitatively eliminated from consideration because of the types of radionuclides reported, their low concentrations, and the shielding power of water.

0474

Proximal Exposure

Exposures from radioactive material can occur when an individual is near or "proximal" to a radioactive source. Physical contact with a contaminated exposure medium is not necessary. These exposures increase as a receptor gets closer to the source of the radioactivity, so the exposures are related to the distance from the source. Penetrating radiation is the major concern in Operable Unit 1.

Using the Great Miami River for Drinking, Domestic, Agricultural, and Recreational Purposes

The Great Miami River is large enough to serve as a water supply for a small farm located near its banks. This water could be used for drinking, showering, cooking, irrigation of food crops, irrigation of animal feed, stock water, and recreational purposes such as swimming and fishing. Exposure routes could include ingestion, inhalation during showering, dermal contact, and food ingestion (including fish). Penetrating radiation from contaminated water was qualitatively eliminated from consideration because of the types of radionuclides reported, their low concentrations, and the shielding power of water.

E.3.3.2.4. Receptors

The future exposure scenarios consider predicted levels of contamination, the activities of future receptors, and the access restrictions placed on these hypothetical receptors. Because contamination can migrate through environmental media over time, the number of receptors and locations that may be of concern increases. Future exposure scenarios are grouped into current land use without access controls and future land use categories.

Receptors Considered Under Current Land Use Without Access Controls

This group of land users reflects the possibility that governmental or industrial use of the property continues, but without perimeter security. Maintenance on the site is assumed to cease, but no capital improvements are considered. All receptors are considered to be exposed to predicted levels of contamination based on the site conditions described in Section E.3.4.1. The following receptors are considered:

- Off-Property RME Farmer — This hypothetical receptor is assumed to live immediately adjacent to the FEMP property boundary. This receptor is affected only by those contaminants that are subject to environmental transport.
- Trespassing Child — This hypothetical receptor is an older child aged 6 to 17. He is not restricted by access controls, and therefore is considered to frequently play on the property. Direct contact with contaminated media can occur.
- Great Miami River User — This receptor lives immediately adjacent to the Great Miami River, downstream of the site. The major concern for this receptor is the exposure that could occur from regular use of the river water for drinking, domestic, agricultural, and recreational purposes.

- Off-Property User of Meat and Milk — This receptor is an off-property resident who uses animal products from livestock grazed and watered on Operable Unit 1. It is described in the Work Plan Addendum (WPA) (DOE 1992a) as the on-property grazing receptor.

Receptors Considered Under Future Land Use

Governmental use and control of the property could cease at some time in the future. This could conceivably allow individuals to enter the property, improve it, and take up permanent residence. In addition, contamination can migrate through environmental media over time. This increases the number of receptors and locations in which exposure could occur. Receptors who could be exposed if governmental use of the property ceases and it is released to the public with no restrictions are:

- On-Property RME Resident Adult — This receptor is an adult living and working on property. This adult uses water from an on-property well for drinking and domestic purposes, and consumes vegetables, fruit, meat, and dairy products produced on site.
- On-Property RME Resident Child — Young children living on property are a subpopulation of concern because they may be more sensitive to a given exposure than an adult. A young child (0 to 6 years age) residing on former FEMP property could be exposed directly to unremediated on-property soil and waste storage areas as a result of either natural environmental processes or human activities. This hypothetical child is assumed to use water from an on-property well for drinking and domestic uses, as well as to consume vegetables, fruit, meat, and dairy products produced on site.
- On-Property Central Tendency (CT) Resident Adult — This scenario considers the risks to an on-property adult resident exposed via the same pathways as the RME resident adult, but with exposure parameters that are more representative of a central tendency. This CT scenario is evaluated to estimate risks that may be more representative of a typical future on-property resident.
- On-Property Home Builder — This receptor is assumed to be a construction worker or future resident involved in building a home in the Operable Unit 1 area.

E.3.3.2.5 Complete Exposure Pathways

This section summarizes the complete exposure pathways for the future source term conditions (i.e., erosion of caps, no operational runoff control system, and under future land use a home built on-property). Complete exposure pathways considered in the risk assessment are summarized in Table E.3-2. In Section E.5, risks will be determined for each complete exposure pathway, and all pathways will be summed for each receptor.

E.3.3.2.6 Exposures Under Current Land Use without Access Controls

As with the current source term evaluation, the RME receptor under this scenario is the off-property resident. Again, this receptor is exposed only to those contaminants that are transported to the receptor location. The following exposure pathways are considered in the risk assessment:

0476

4782

- Domestic use of groundwater — Assuming that the waste pits and the Clearwell continue to exist and act as source areas of contamination, downgradient groundwater supplies could eventually be affected. Groundwater that is contaminated via leachate generation from the waste storage area could migrate to a downgradient receptor location. There a well could be installed to serve a home, and the residents could be exposed via ingestion, inhalation of volatiles and/or radon emitted during showering, and dermal contact during bathing or showering. 1
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- Agricultural use of groundwater — This pathway assumes groundwater is used to grow food. Irrigation of crops and animal feed results in foliar deposition of contaminants onto plants and uptake on contaminants by plant roots. These plants are later harvested and eaten by humans or fed to livestock. This livestock also ingested soil contaminated by aerial deposition. Meat and milk from these animals are later consumed by humans. 8
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- Inhalation of radon, volatiles, and particulates — Fugitive dust and gaseous emissions from the waste pit area could migrate off property and affect local residents. These receptors would not only be exposed directly to these emissions via inhalation, but could also be exposed via fallout onto soil and plants. The contaminants in the fallout could be transferred to edible plant material, and reach the receptor upon ingestion. 13
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- Food Contaminated by Aerial Deposition — This pathway assumes aerial suspension of exposed soil/waste, followed by foliar deposition onto plants. These plants are later harvested and eaten by humans. These plants are also used as forage and stored feed by livestock. Meat and milk from these animals are later consumed by humans. 18
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Several other pathways are considered for this receptor, but are determined to present a minimal risk in comparison with the above pathways. These include inhalation of volatiles (the source concentration in surficial materials is minimal) and exposures to water in the Great Miami River (receptor is assumed to not leave his home on a routine basis). 22
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A trespassing child was also considered under the future source term/current land use configuration. This receptor is assumed to be exposed soil, waste pit materials, air, and sediment while on property or playing in Paddy's Run, as follows: 26
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- Direct exposure to soil and waste pit contents — Given the lack of access controls considered under this scenario, a trespassing child could routinely be exposed to surface soil and exposed waste pit materials. Penetrating radiation exposures from either buried or exposed radioactive materials is considered to be a significant route of exposure, as are incidental ingestion and dermal contact with soil or exposed wastes. 29
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- Inhalation of radon, volatiles, and PM-10 particulates — While the concentrations of volatiles are not expected to be significant for a local receptor based on the modeling results, the presence of radon and particulates could result in a quantifiable exposure. The air concentrations to which a receptor could be exposed are based on the modeling discussed in Appendix D. 34
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- Direct contact with sediment in Paddy's Run — With the runoff control system no longer in operation, soil could be eroded from the site and enter Paddy's Run. At this point, trespassing children are the most likely receptors. They could be exposed via incidental ingestion or via dermal contact. Penetrating radiation exposures to these dispersed source materials would be less significant. Surface water exposure is not considered, as Paddy's Run is not a permanent flowing stream in the vicinity of Operable Unit 1.

The trespassing child is assumed to use off-site water sources unaffected by contamination from Operable Unit 1 as potable water supplies, and therefore would not experience ingestion, inhalation, or dermal contact exposures, nor would he be exposed indirectly through ingestion of fruit, vegetables, meat, or milk contaminated via aerial deposition or on-site grazing or watering. For reasons mentioned previously (i.e., algae), exposures to water in the Clearwell would be limited to accidental, irregular acute exposures that result in a minor risk in comparison to the pathways described above.

The third receptor considered under the future source term, current land use scenario is the Great Miami River user. This receptor was developed to provide information on risks incurred by distant (hypothetical) receptors whose only mode of contact with Operable Unit 1 contamination is via runoff of soil and surface water to Paddy's Run and the Great Miami River, where unsuspecting receptors could be exposed. The following exposure pathways are considered:

- Domestic use of Great Miami River water — The Great Miami River is a water body of adequate size and reliable supply to provide a source of potable water for a home located on the river. Receptors in this home could conceivably be exposed via ingestion, inhalation of volatiles and radon during showering, and dermal contact while bathing. Penetrating radiation in this supply would result in a minimal risk.
- Agricultural use of Great Miami River water — This pathway assumes Great Miami River water is used to grow food. Irrigation of crops and animal feed results in foliar deposition of contaminants onto plants and uptake on contaminants by plant roots. These plants are later harvested and eaten by humans or fed to livestock. This livestock also ingested soil contaminated by aerial deposition. Meat and milk from these animals are later consumed by humans.
- Exposure while swimming — It is likely that persons swimming in the Great Miami River could experience both an incidental ingestion and a dermal exposure to contaminants originating at Operable Unit 1. Sediment exposure is not considered, as Paddy's Run has not been shown to transport contaminated sediment all the way to the river.
- Ingestion of fish from the Great Miami River — Local residents could catch fish in the river whose edible tissue has bioaccumulated Operable Unit 1-related contaminants.

The final receptor considered under the future source term, current land use scenario is the off-property user of meat and milk produced on site. The exposure pathways for this isolated receptor are discussed in Section E.3.3.6.2, and are listed below:

- Ingestion of meat and milk contaminated via root uptake from soil and subsequent grazing
- Ingestion of meat and milk contaminated via aerial deposition onto soil and feed crop plant surfaces
- Ingestion of meat and milk contaminated via direct ingestion of surface water by cows

E.3.3.2.7 Exposures Under Future Land Use

This scenario involves a completely separate set of receptors, as discussed in Section E.3.3.2.4. The purely hypothetical scenario involves construction of a home on property (exposure of a construction worker) and on-site residents (adults and children) living in the vicinity of Waste Pit 4. A well is assumed to be drilled to supply the domestic and agricultural needs of this family. These scenarios are also included in Table E.3-2 and are summarized below.

There are two scenarios evaluated for the on-site adult resident farmer, as outlined previously. The first is the RME scenario, which is intended to evaluate the reasonable maximum exposures that would be expected to occur; the second is the CT scenario, which is intended to evaluate a more central tendency set of exposures. In addition, an on-property resident child is also considered. The exposure pathways evaluated for the on-property resident farmer and child are as follows:

- Domestic use of groundwater from the Great Miami Aquifer — This scenario is based on the assumption that a well could be installed at some time in the future, should all governmental control of the property cease. This well is assumed to be drilled in the vicinity of Waste Pit 4, which contains the highest concentrations of contaminants. The contaminant concentrations used in this scenario are based on modeling to ascertain the risks associated with only the Operable Unit 1 source areas. Actual concentrations are addressed in the Operable Unit 5 risk assessment. A receptor is assumed to be exposed via ingestion, inhalation of volatiles during showering, and dermal contact while bathing. As mentioned under the current source term model, penetrating radiation from water would result in an insignificant exposure for which no calculation methods exist.
- Agricultural use of Great Miami Aquifer water — This pathway assumes Great Miami Aquifer water is used to grow food. Irrigation of crops and animal feed results in foliar deposition of contaminants onto plants and uptake on contaminants by plant roots. These plants are later harvested and eaten by humans or fed to livestock. This livestock also ingested soil contaminated by aerial deposition. Meat and milk from these animals are later consumed by humans.

- Ingestion of water from the perched aquifer — Because this aquifer does not contain enough water to provide a continuous supply of potable water, only ingestion was considered to evaluate exposures to this water, at the request of EPA Region V. The contaminant concentrations to which receptors could be exposed are based on the results of the groundwater modeling discussed in Appendix D.
- Ingestion of meat and milk produced on property — Several variations of this exposure pathway are considered for the on-property resident, as for the off-property user of meat and milk. These scenarios are 1) root uptake by feed crops from buried or exposed waste pit contents and 2) direct ingestion of on-property surface water by cows. The meat and milk from these cows would be ingested by on-property residents.
- Ingestion of food contaminated by aerial deposition — This pathway assumes aerial suspension of exposed soil/waste, followed by foliar deposition onto plants. These plants are later harvested and eaten by humans. These plants are also used as forage and stored feed by livestock. Meat and milk from these animals are later consumed by humans.
- Direct contact with soil or waste pit material — While routinely engaged in farming activities (adults) or playing on-property (children), receptors could experience an exposure to contaminated surface soil (Waste Pits 1, 2, 4, and the Burn Waste Pit) or exposed waste pit material (Waste Pits 3, 5, and 6). Exposures could occur via incidental ingestion or dermal contact.
- Proximal exposure to buried or exposed radioactive sources — This exposure scenario incorporates exposures to either buried or exposed radioactive pit materials.
- Direct contact with sediment — It is also possible that adult receptors only (the resident child receptor is assumed to be aged 6 and under, and Paddy's Run is 1,000 feet from the home site) could come in contact with contaminated sediment in Paddy's Run if the runoff control system is no longer in operation. Exposures could occur via incidental ingestion and dermal contact, however, these exposures are expected to be infrequent in comparison to exposures around the home and fields.

In addition, it is assumed that the adult receptors would not swim in the remaining surface water on property (the Clearwell or Waste Pits 5 and 6) given the assumption that these water bodies are only half-filled with water and contain debris and algae. Small children living on property are also assumed to not be exposed, as they are too young for unsupervised swimming and the water bodies are not attractive. It is recognized that intermittent, accidental exposures to surface waters could occur, but that the intakes from these exposures would be minimal in comparison to those from the routes and pathways described above.

Other potential pathways such as penetrating radiation from air or from materials deposited on plant surfaces would be insignificant.

The home builder (construction worker) was also evaluated for this scenario. This receptor is assumed to be exposed only while on property, and to use unaffected off-property sources for potable water supply and food. Therefore, his/her only exposures are assumed to be related to direct contact scenarios, as follows:

- Proximal exposure to buried waste pit contents — Exposure to penetrating radiation from these source areas could occur while the receptor is involved in construction activities of a limited duration.
- Direct contact with surface soil — This exposure pathway considers the potential exposures of an on-property home builder. Exposures could occur via incidental ingestion of or dermal contact with non-radiological contaminants.
- Inhalation of radon, volatiles, and particulates — While the surficial concentrations of volatile organic chemicals are minimal, exposures to radon and particulates could be significant. These exposures are assumed only to occur during the limited time this receptor is on property.

E.3.4 EXPOSURE POINT CONCENTRATIONS

The exposure point concentration is the concentration of a contaminant in an exposure medium that may be contacted by a real or hypothetical receptor. Determination of the exposure point concentration depends on several factors, such as:

- Availability of data
- Amount of data available to perform statistical analysis
- Background concentrations not attributed to the site
- Location of the potential receptor.

Current exposure concentrations for Operable Unit 1 are determined in two different ways. First, measured concentrations are used for current potential exposures to the waste pits and surrounding surface soils. Second, measured concentrations are used as input to air transport models. To be consistent with the concept of the RME scenario, an estimate of the highest exposure that can reasonably be expected to occur requires a reasonable maximum estimate of the concentration of each contaminant in each exposure medium. Because of the uncertainty associated with any estimate of exposure concentrations, the upper 95 percent confidence limit on the arithmetic mean for either a normal or lognormal distribution is the recommended statistic (concentration value) to be constructed from measured contaminant concentration data and used in risk assessments (EPA 1992c). This term is generally called the upper confidence limit (UCL). The methodology used to calculate the UCL is discussed in Section 7.1.1 of the Work Plan Addendum (DOE 1992a), and summarized in Section E.2.0 of this report.

For future exposures to soil, groundwater, or air, surface soil and subsurface soil concentrations (UCLs) were used to approximate exposure point concentrations. Fate and transport models presented

in Section 5.0 of the Operable Unit 1 RI Report were used to predict exposure point concentrations for future exposures to groundwater, surface water, and sediment, and for exposures to selected constituents in air. In addition, equilibrium conditions are considered for radionuclides.

Several of the scenarios evaluated incorporate an area-weighted average concentration rather than waste pit-specific results. These types of scenarios, such as the adolescent trespasser or the site visitor, are based on the assumption that a receptor will move throughout the site. Therefore, an overall average UCL concentration is considered appropriate as an exposure concentration.

E.3.4.1 Surface Soil

Exposure point concentrations for current surface soil exposure pathways (such as the site visitor) are the UCLs determined from measured surface soil data. Table E.3-3 presents both the CPCs and the UCLs that are used to assess the exposures associated with surface soil at Operable Unit 1. These surface soil concentrations are also used in the future source term to evaluate exposures to crops grown on Pits 1 and 2.

E.3.4.1.1 Radioactive Contaminants

Fourteen radionuclides were detected in Operable Unit 1 surface soils. Eight of these are naturally occurring radionuclides from the uranium, thorium, and actinium decay series (U-238, U-235, U-234, Th-232, Th-230, Th-228, Ra-226, and Ra-228). The remaining radioisotopes (Cs-137, Sr-90, Tc-99, Pu-238, Pu-239/240, and Np-237) are produced by nuclear processes such as those found in a nuclear reactor. The radionuclides reported in the highest concentration are U-238, U-234, and Th-230.

E.3.4.1.2 Chemical Contaminants

The chemicals listed for evaluation in this risk assessment reflect the results of comparing on-property concentrations to background concentrations. Sixteen metals and Aroclor-1254 were detected in Operable Unit 1 surface soils and selected as CPCs. While several metals were present at concentrations only slightly greater than the background concentrations (e.g., arsenic), uranium was found at a notable concentration of 52.2 mg/kg.

E.3.4.2 Exposed Waste Pit Material

The eight waste pits contain a heterogeneous mix of chemicals reflecting the history of the processes carried out at the FEMP. These waste pits contain materials which can migrate through groundwater. In addition, if the caps and covers over these waste pits erode or are disturbed during construction of a home, the contents of these waste pits will be exposed, and exposures could occur in the same way as to surface soils. Thus, this assessment considers the UCLs of the subsurface soils and wastes in combination with the existing surface soil as the exposure point concentrations for future. In the future source term conceptual site model, the waste in Waste Pits 3, 5, and 6 will be exposed, but the

4787

soil covers will remain intact over the remainder of Operable Unit 1. Table E.3-4 presents the waste pit soil/waste concentrations that are used in the future exposure scenarios.

E.3.4.2.1 Radioactive Contaminants

In the future, radioactive decay will alter the detected concentrations in Operable Unit 1. To account for this, only those nuclides with half-lives greater than 25 years are explicitly evaluated. All shorter-lived nuclides are assumed to be in equilibrium with their longer-lived precursors and are included when risks to the parent nuclide is evaluated in the risk characterization phase of this assessment. Twelve radionuclides with half-lives greater than 25 years were detected in concentrations exceeding background levels in Operable Unit 1 waste pit sludge/soils. Six of these (U-238, U-235, U-234, Th-232, Th-230, and Ra-226) are naturally occurring radionuclides from the uranium, thorium, and actinium decay series. The remaining radioisotopes (Cs-137, Sr-90, Tc-99, Pu-238, Pu-239/240, and Np-237) are produced by nuclear processes such as those found in a nuclear reactor. The radionuclides reported in the highest concentrations are U-238, U-234, and Th-230.

E.3.4.2.2 Chemical Contaminants

The chemicals listed for evaluation in this risk assessment reflect the results of applying the screening techniques described in Section E.2.0 of this appendix. Four distinct groups of chemicals were detected at significant levels: 1) polycyclic aromatic hydrocarbons (PAHs); 2) polychlorinated biphenyls (PCBs); 3) dioxins and furans; and 4) metals. A total of 22 metals were detected in the three waste pits of concern and the remaining surface soils and were selected as CPCs, as well as two PCBs, six PAHs, seven dioxins/furans, pentachlorophenol, and tetrachloroethene. Because the future land use scenarios are based on the assumption that exposures could occur throughout the source area, an area-weighted average concentration was developed using the full area of Waste Pit 3 and other soils, and one-half the area of Waste Pits 5 and 6 (assuming half the waste pit material is exposed).

E.3.4.3 Waste Pit 4 Material

The future land use scenario considers the possibility that a home could be constructed on Pit 4, which is physically the most stable area of Operable Unit 1. It is assumed that once construction is complete, that topsoil would be emplaced for lawns. The pit is currently covered with a RCRA cap and synthetic cover, which are unsuitable for vegetative growth.

E.3.4.3.1 Radioactive Contaminants

Fourteen radionuclides were detected in the contents of Pit 4. As discussed in Section E.3.4.1.1, several of these are naturally occurring radionuclides. As with the other future scenarios, only nuclides with half-lives greater than 25 years are evaluated. Therefore, only 11 radionuclides were selected for this exposure scenario.

0483

E.3.4.3.2 Chemical Contaminants

The chemicals selected as CPCs for quantitative evaluation include 18 metals and 30 organics. The organics include numerous PAHs, dioxins, furans, and PCBs.

E.3.4.4 Buried Pit Materials

Several of the defined exposure scenarios require the evaluation of penetrating radiation risks from buried waste pit contents. The buried contents of the waste pits produce radiation which can expose humans on the ground surface. To assess the magnitudes of these exposures, a computer code called Microshield (Grove Engineering, 1987) is used, as required by the WPA (DOE 1992a).

Microshield is capable of calculating the radiation dose rate for a variety of source and shield geometries, source materials, shield materials, and shield thicknesses. A limited amount of input information is required. Required input for Microshield includes information on the source, the types and concentrations of radionuclides present in the source being modeled, the shape and physical dimensions of the source and its cover (if any), and the density and physical makeup of the source and cover, and the distance from the source to the receptor.

The inventory of radionuclides is determined using the CPC tables in Section E.2.5. The physical characterization data required is obtained from the nature and extent section of the RI. The physical dimensions of the buried sources and any cover they may have is determined from the waste pit cross-sections provided in the RI. In most cases, the sources investigated have irregular shapes. A cylindrical source geometry with a volume and surface area equivalent to the irregularly shaped source is used for these calculations. This geometry produces the maximum dose rate for a given surface area. The distance to the receptor point is assumed to be one meter above the ground surface at the center of the source.

Microshield runs are performed on both current and future source term configurations as shown in Tables E.3-6 and E.3-7, respectively. The results of these computer runs are presented in Table 3-8.

E.3.4.5 On-Property Surface Water

Three open waste ponds located in Operable Unit 1 currently contain standing water. Weighted average exposure point concentrations for current surface water exposure pathways are based on the UCLs determined from measured surface water data. Table E.3-9 presents the measured and weighted average concentrations from these ponds which are used to assess the current exposures associated with surface water currently in Operable Unit 1, such as watering of livestock. Table E.3-10 presents the concentrations for the future scenarios, which were adjusted using the reduced surface areas.

787

E.3.4.5.1 Radioactive Contaminants

Nine radionuclides were detected in the three ponds. The highest reported UCLs are associated with U-238, U-234, and Tc-99. Of these, Tc-99 is of particular concern because of its mobility and ability to move through the human food chain. Concentrations of this nuclide are highest in the Clearwell and Waste Pit 6.

E.3.4.5.2 Chemical Contaminants

The list of chemicals detected in surface water includes eleven metals and benzene. Analytes found at the highest concentrations are vanadium and zinc, which were found at maximum concentrations of approximately 100 g/L. The weighted average concentrations of most metals were not above the MCLs.

E.3.4.6 Off-Property Surface Water

Constituent concentrations the Great Miami River were predicted using fate and transport modeling. Table E.3-11 lists the chemicals evaluated in the risk assessment and their predicted concentrations for the future source term. Section 5.0 of the Operable Unit 1 RI Report describes the model and modeling results in detail.

E.3.4.6.1 Radioactive Contaminants

The potential concentrations of eleven radionuclides in the Great Miami River are based on the assumption that the existing runoff control system no longer functions. Only U-238, U-235, U-234, Tc-99 are predicted to be present in the river at levels that are detectable using standard analytical techniques. All but U-238 and Tc-99 would be indistinguishable from background.

E.3.4.6.2 Chemical Contaminants

All the chemicals of significance (toxic or carcinogenic compounds) detected in surface soil were modeled via surface water and sediment transport into the Great Miami River. With the exception of uranium, most concentrations are well below standard analytical detection limits.

E.3.4.7 Sediment

Contaminants in sediments currently found in Paddy's Run are being assessed by Operable Unit 5, therefore, exposure point concentrations for future sediment exposures associated with contributions from Operable Unit 1 are determined by modeling. Table E.3-12 presents the predicted sediment concentrations with sediment assumed to exist in Paddy's Run in the future.

E.3.4.7.1 Radioactive Contaminants

Radioactive contaminant concentrations in the sediment of Paddy's Run are predicted, through modeling, to be dominated by U-238, U-234, and Th-230. The greatest concentration listed in Table E.3-12 is associated with U-238, and the least with Pu-239/240.

E.3.4.7.2 Chemical Contaminants

The chemicals listed for evaluation in this risk assessment reflect the results of applying the screening technique described in Section E.2.0 of this appendix. All the chemical concentrations predicted in Paddy's Run are the same as the surface soil concentrations.

E.3.4.8 Groundwater

Current groundwater contamination is being assessed by Operable Unit 5. The Operable Unit 1 risk assessment is limited to investigating the future migration of groundwater from the sources within the operable unit boundaries and include evaluation of both the perched water and the Great Miami aquifer.

Future exposure point concentrations for groundwater are determined from the results of geochemical and groundwater transport modeling, as described in Section 5.0 and Appendix D of the Operable Unit 1 RI Report. The geochemical and groundwater models and parameters are designed to provide high confidence that the risks attributed to the transport of contaminants in the groundwater will not be greater than the calculated values. These results are conservative and are not likely to actually occur.

This assessment focuses on chemicals that contribute significantly to the risks associated with groundwater exposures. This is done by examining predicted chemical concentrations in leachate seeping through the vadose zone (Section 5.1 of the Operable Unit 1 RI Report). A chemical carcinogen was selected for aquifer modeling and a detailed risk evaluation if its predicted concentration in the leachate before dilution in the aquifer was greater than 10 percent of EPA Region III screening values (EPA 1993b), which are based on an ingestion rate of 2 L/day for 30 years, or a 10^{-6} risk. Since there are currently no screening levels for radionuclides, screening levels were developed for the drinking water pathway using a target risk of 10^{-7} in the leachate and a drinking water ingestion rate of 2 L/d over 70 years. The volume of water in the aquifer dilutes chemical concentrations in the leachate by at least a factor of 10, so the concentrations of carcinogens that were not selected are estimated to contribute risks of no more than 10^{-8} . Noncarcinogens were selected if the estimated concentration in the water would yield an intake equal to 10 percent of the screening value for noncarcinogens assuming the leachate was ingested at a rate of 2 L/day for 70 years. Dilution by aquifer water ensures that the exposure point concentrations of noncarcinogens that were not selected for a detailed evaluation will be less than 1 percent of the allowable intake for the noncarcinogen.

Table E.3-13 presents the predicted concentrations in groundwater both on property and just beyond the downgradient FEMP property boundary line. This table also includes the maximum contaminant concentrations in the perched water beneath the site. Development of the exposure concentrations via modeling was discussed in detail in Appendix D. The locations of calculated maximum on- and off-property risk associated with groundwater exposure shown in Figure E.3-4.

This table also includes the maximum predicted contaminant concentrations in the perched water beneath the site. Development of the exposure concentrations was discussed in detail in Appendix D.

E.3.4.8.1 Radioactive Contaminants

In the perched water, U-234, U-235, U-238, Th-232, and Tc-99 are predicted at the greatest concentrations. Concentrations were converted to activities in Table E.3-13. The maximum concentration are occurring at the present time.

The groundwater modeling results predict that three isotopes of uranium and Tc-99 will be of concern for hypothetical future on-property residents. The activity of U-238 is three times greater than the activity of all other radionuclides together. The maximum risk is predicted to occur about 680 years from the beginning of the modeled period.

Only isotopes of uranium and Tc-99 are predicted to reach the off-property boundary in concentrations which might be detectable by standard analytical techniques. Of these radionuclides, U-238 is expected to exhibit the highest activity in the hypothetical off-property well. These are predicted to occur about 680 years from now.

E.3.4.8.2 Chemical Contaminants

The results of the groundwater modeling produce a list of chemical constituents that includes both inorganics and organics. The principal inorganics include uranium, nickel, and boron in the perched aquifer. Based on existing concentrations in individual wells in the Greater Miami aquifer, arsenic, and barium are also found significant concentrations.

Only two organic compounds (tetrachloroethane and dichlorodifluoromethane) are predicted to reach the Greater Miami aquifer. Vinyl chloride and Aroclor-1221, both of which passed the screening criteria, were not predicted to be present at the time of overall maximum risk (630 years).

E.3.4.9 Air

Airborne concentrations of contaminants from the waste storage areas of Operable Unit 1 were modeled for both current and future conditions at on-property and off-property locations. The model assumes mass loading (fugitive dust emissions) from surface soil, gas emission (radon and volatiles) to the air from each waste pit area, and the subsequent transport and dispersion of these contaminants. The model and parameters for air dispersion are described in Section 5.0 of the Operable Unit 1 RI Report.

Table E.3-14 lists the current on-property and off-property air concentrations for the current source term conditions, and Table E.3-15 lists those estimated for the future source term conditions. The

chemicals listed for evaluation in this medium are those listed as CPCs in the surface soil and/or exposed waste pit materials. The locations of calculated maximum risk are shown in Figure E.3-4.

Only the PM-10 fraction was modeled. Actual deposition rates were not modeled for the Operable Unit 1 area, but a maximum deposition velocity and rate based on a worst case rate determined for the active flyash pile (Operable Unit 2) was used in food chain calculations.

E.3.4.9.1 Radioactive Contaminants

The highest annual average current air concentrations are used to evaluate potential exposures. Rn-222 currently produces the greatest on- and off-property concentrations, with no other radionuclide being within two orders of magnitude. Both on- and off-property maxima were reported.

The highest annual average future air concentrations are used to evaluate potential future exposures. These concentrations are generated from the future source term soil concentrations. Off-property air concentrations are less than the on-property concentrations by one to two orders of magnitude for most radionuclides.

E.3.4.9.2 Chemical Contaminants

The list of chemicals selected for air modeling included chemicals detected in surface and/or subsurface soil and waste pit material. The primary chemical contaminants for the air pathway include barium, manganese, nickel, and vanadium. Under future conditions, uranium and arsenic are also predicted at the receptor locations at notable concentrations. The concentrations of all organics are on the order of 10^{-7} mg/m³ for both current and future conditions.

E.3.5 QUANTIFICATION OF EXPOSURE

Estimates of exposure are based on the contaminant concentrations at the exposure points (described in Section E.3.4) and scenario-specific assumptions and intake parameters. The models and equations used to quantify intakes are described in the Risk Assessment Work Plan Addendum (DOE 1992a) and have been obtained from EPA risk assessment guidance (EPA 1989a). In cases where models were not available from EPA, models developed by the U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.109 (NRC 1977) were used.

The method used to quantify chronic exposures at the FEMP employs the concept of the RME for each of the four land use/source term scenario combinations. The RME is the maximum exposure reasonably expected to occur at the site (EPA 1989a). If the RME is determined to be acceptable, then it is likely that all other lesser exposures at the site will also be acceptable. Exposures for the on-property resident are also evaluated using the CT analysis. This analysis represents exposures under more typical situations and exposure parameters are selected accordingly.

787

Exposures are dependent on measured or predicted concentrations of chemicals in environmental media and local land-use practices, and both are subject to change over time. This results in a large number of possible combinations of media, receptors, exposure pathways, and concentrations. Tables E.3-1 and E.3-2 presented the combinations of receptors, land-use conditions, and concentrations (current or future) evaluated in this exposure assessment.

Exposure model parameters used in the Operable Unit 1 risk assessment are presented in Tables E.3-16 and E.3-17 for the current and future source term receptors, respectively. All parameters and equations are discussed in the FEMP Risk Assessment Work Plan Addendum (DOE 1992a) unless noted otherwise. Current and predicted future exposure point concentrations, which are combined with receptor-specific exposure parameters, are used to calculate intakes and risks.

This section presents the equations used to quantify the magnitude of exposure expected to result from all reasonable exposure pathways at the FEMP. Exposures are quantified using a set of equations and parameters which are unique to each exposure pathway. The exposure assessment process results in calculated daily intakes expressed as milligrams of chemical per kilogram of body weight per day (mg/kg-d) for hazardous chemicals and radioactivity intakes (expressed in pCi) for radionuclides.

E.3.5.1 Equations Quantifying Intakes and Exposures to Soil or Sediment

E.3.5.1.1 Incidental Ingestion

The estimation of intake of contaminants in soils or sediment is determined using the concentration in the soil or sediment at the location of interest. Evaluation of the soil and sediment ingestion pathway is performed for adults and children. Children represent a critical subpopulation for whom these exposure pathways may be significant. EPA guidance suggests that children may be exposed through the soil ingestion pathway at ages 1 through 6 (EPA 1989a). It is assumed that ingestion of sediments in stream beds away from the home involves slightly older children at ages 6 through 17. Evaluation of the soil/sediment ingestion pathway is performed using Equations 7-7 and 7-8 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992a):

$$\text{(radionuclides)} \quad I_{si} = (C_{si})(IR)(ED)(EF)(FI) \quad (\text{E.3-1})$$

$$\text{(chemicals)} \quad I_{si} = (C_{si})(IR)(CF)(FI)(EF)(ED)/(BW)(AT) \quad (\text{E.3-2})$$

where

- I_{si} = intake from soil or sediment for contaminant i (pCi, rad) (mg/kg-d, chem)
- C_{si} = concentration of contaminant i in soil or sediment (Pci/g, rad) (mg/kg, chem)
- IR = ingestion rate (g/d, rad) (g/d, chem)
- CF = conversion factor 10^{-3} kg/g
- FI = fraction ingested from contaminated source (unitless)
- EF = exposure frequency (d/y)
- ED = exposure duration (y)

BW = body weight (kg)
 AT = averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)

E.3.5.1.2 Dermal Contact

The estimation of intake of organic contaminants in soils or sediment via absorption through the skin is determined using the concentration in the soil or sediment at the location evaluated. Evaluation of the dermal absorption pathway is performed for adults and children. Children represent a critical subpopulation for whom these exposure pathways may be significant. EPA guidance suggests that children may be exposed through the dermal contact pathway at ages 1 through 6 (EPA 1989a). It is assumed that contact with sediments in stream beds away from the home involves slightly older children at ages 6 through 17. Dermal absorption from these sources is calculated using Equation 7-25 of the FEMP Risk Assessment Work Plan Addendum (DOE 1992a):

$$AB_{si} = (C_{si})(CF)(SA)(AF)(ABS)(EF)(ED)/(BW)(AT) \quad (E.3-3)$$

where

AB_{si} = amount of i^{th} constituent absorbed during contact with soil or sediment (mg/kg-d)
 C_{si} = concentration of i^{th} constituent in soil or sediment (mg/kg)
 SA = skin surface area available for contact ($cm^2/event$)
 AF = skin adherence factor (mg/cm^2)
 ABS = absorption factor (unitless)
 CF = conversion factor, (10^{-6} kg/mg)
 EF = exposure frequency (events/y)
 ED = exposure duration (y)
 BW = body weight (kg)
 AT = averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)

E.3.5.1.3 Direct Radiation Exposure

The estimation of direct radiation exposure from soils or sediment is determined using the concentration in the soil or sediment at the location evaluated. Since the publication of DOE 1992a, EPA has published a new set of slope factors (EPA 1992b). Changes in these slope factors require the use of a different equation than the one originally presented in DOE 1992a to calculate risks resulting from external radiation exposures from soils. The new equation is:

$$TX = (C_s)(ED)(EF)(CF)[ET_{in} (1-S_i) + ET_{out} \times (1-S_o)] \quad (E.3-4)$$

where

TX = time dependent activity concentration (pCi-y/g-lifetime)
 C_s = concentration in surface soil or sediment (pCi/g)
 ED = exposure duration (y/lifetime)
 EF = exposure frequency (d/y)

ET_{in}	=	exposure time indoors on-site (h/d)	1
ET_{out}	=	exposure time outdoors on-site (h/d)	2
S_i	=	indoor shielding factor (0.5, from <u>Risk Assessment Work Plan Addendum</u>)	3
S_o	=	outdoor shielding factor outdoors (0, assumes no shielding)	4
CF	=	1.142×10^{-4} y/h	5

Radionuclides are not evaluated as a dermal exposure because their mechanism of action differs (i.e., penetrating radiation differs from dermal absorption). Dermal absorption of organic chemicals was discussed in the preceding section.

E.3.5.2 Equations Quantifying Intakes and Exposures from Water

E.3.5.2.1 Water Ingestion Pathway

A receptor can ingest water by deliberately drinking it, or by accidentally swallowing water while swimming. An estimate of intake from ingesting water is calculated from Equations 7-3 and 7-4 of DOE 1992a. The intake equations are:

$$\text{(radionuclides)} \quad I_{wi} = (C_{wi})(IR)(FI)(ED)(EF) \quad (\text{E.3-5})$$

$$\text{(chemicals)} \quad I_{wi} = (C_{wi})(IR)(FI)(ED)(EF)/(BW)(AT) \quad (\text{E.3-6})$$

where

I_{wi}	=	intake of i^{th} contaminant from drinking water (pCi, rad) (mg/kg-d, chem)	17
C_{wi}	=	concentration i^{th} in water (pCi/L, rad) (mg/L, chem)	18
IR	=	ingestion rate (L/d)	19
FI	=	fraction ingested from source (unitless)	20
EF	=	exposure frequency (d/y)	21
ED	=	exposure duration (y)	22
BW	=	body weight (kg)	23
AT	=	averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y [EPA 1991c]); for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)	24 25

E.3.5.2.2 Volatiles Released by Showering and Other Household Water Uses

The amount of a chemical taken into the body via exposure to volatilization of chemicals from showering is evaluated using the concentration of a chemical in the water source, as suggested by EPA (1992a; 1992b). Intake from the volatilization of chemicals in household water is calculated using the Andelman model (EPA 1991f):

$$\text{(radionuclides)} \quad I_{wai} = (C_{wi})(K)(IR_i)(EF)(ED) \quad (\text{E.3-7})$$

$$\text{(chemicals)} \quad I_{wai} = (C_{wi})(K)(IR_i)(EF)(ED)/(BW)(AT) \quad (\text{E.3-8})$$

where

I_{wa}	=	intake of volatile in water from inhalation (pCi, rad) (mg/kg-day, chem)	1
C_{wi}	=	concentration of constituent i in water (pCi/L, rad) (mg/L, chem)	2
K	=	volatilization factor (0.5 L/m ³)	3
IR_i	=	indoor inhalation rate (m ³ /d)	4
EF	=	exposure frequency (d/y)	5
ED	=	exposure duration (y)	6
BW	=	body weight (kg)	7
AT	=	averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y [EPA 1991c]);	8
		for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)	9
			10

For most metals and, hence, most radionuclides at the FEMP, volatilization is not a significant pathway because they do not vaporize at room temperature. The notable exceptions are the isotopes of radon.

E.3.5.2.3 Dermal Contact While Bathing or Swimming

The estimation of intake of contaminants in water via absorption through the skin is determined using the concentration of a chemical in the water source evaluated. Evaluation of the dermal absorption pathway is performed for both adults and children. The amount of a chemical taken into the body upon exposure via dermal contact is referred to as an absorbed dose. The absorbed dose is calculated using the dermal guidance contained in EPA 1989a, EPA 1992e, and EPA 1992h:

$$I_{ws} = (DA_{event})(EV)(EF)(ED)(SA)/(BW)(AT) \quad (E.3-9) \quad 20$$

where

I_{ws}	=	intake through skin from showering (mg/kg-day)	21
DA_{event}	=	absorbed dose per event (mg/cm ² -event)	22
EV	=	event frequency (event/d)	23
SA	=	surface area (cm ²)	24
EF	=	exposure frequency (d/y)	25
ED	=	exposure duration (y)	26
BW	=	body weight (kg)	27
AT	=	averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for	28
		chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)	29
			30

DA_{event} can be calculated as:

$$DA_{event} = (C_v)(2)(K_p)[(6)(TAO)(ET)/\pi]^{+0.5} \text{ if } t_{event} < t^*, \text{ or} \quad (E.3-10) \quad 32$$

$$DA_{event} = (C_v)(K_p)\{[(t_{event})+(2)(TAO)(1+3B)]/(1+B)\} \text{ if } t_{event} > t^* \quad (E.3-11) \quad 33$$

787
where

C_v = concentration in the vehicle (mg/L)
 K_p = permeability constant (cm/h)
 TAO = lag time (h)
 B = partitioning coefficient (unitless)
 t_{event} = time of event (h)
 π = Pi (3.14)
 t^* = time to equilibrium conditions (hr)

For showering the vehicle is domestic water, and for swimming the vehicle is river water. In either case, C_v equals concentration in the water (C_w). For most metals and, hence, most radionuclides in Operable Unit 1, dermal absorption is not a significant pathway because penetration through the skin is minimal.

E.3.5.3 Equations Quantifying Intakes and Exposures from Inhalation

The amount of a contaminant a receptor takes in as a result of respiration is determined using the concentration of a chemical in the air. Equations 7-5 and 7-6 from DOE 1992, are used to quantify intake from the inhalation pathway:

$$\text{(radionuclides)} \quad I_{ai} = (C_{ai})(IR)(ET)(EF)(ED) \quad (E.3-12)$$

$$\text{(chemicals)} \quad I_{ai} = (C_{ai})(IR)(ET)(EF)(ED)/(BW)(AT) \quad (E.3-13)$$

where

I_{ai} = intake from inhalation (pCi, rad) (mg/kg-d, chem)
 C_{ai} = concentration in air (pCi/m³, rad) (mg/m³, chem)
 IR = inhalation rate (m³/h)
 ET = exposure time (h/d)
 EF = exposure frequency (d/y)
 ED = exposure duration (y)
 BW = body weight (kg); and
 AT = averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)

E.3.5.4 Equations Quantifying Intakes and Exposures from Food

Consumption of contaminated food may contribute a measurable portion of the chemical intake experienced by a receptor from Operable Unit 1 at some time in the future. The food sources evaluated in this assessment include vegetables and fruit, beef, dairy products, and fish.

Transport through the food chain to humans is a concern at this operable unit, mainly under future conditions. Under current conditions humans are not expected to directly ingest vegetation growing within the operable unit. However, in the future, animals could be released within the operable unit to

graze. In addition, contaminated water could be used to irrigate crops or feed, or used to water livestock. By these mechanisms, contaminants could find their way into the human food chain.

Contaminant concentrations in food can be estimated using the equations presented below. These methodologies are taken from the Work Plan Addendum (DOE 1992a).

E.3.5.4.1 Vegetable and Fruit Ingestion

The amount of a contaminant a receptor takes in as a result of consuming vegetables and fruit is determined using the concentration of a chemical in the edible portions of the plants.

The concentration in vegetables and fruit attributable to contaminated irrigation water is estimated using Equation 7-9 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992a):

$$C_{vwi} = d_w \left[\frac{r_w(1 - e^{-\lambda_w t})}{Y\lambda_w} + \frac{f_w B_{iv(2)} C F_p (1 - e^{-\lambda_{di} t_{bw}})}{\rho \lambda_{di}} \right] e^{-\lambda_{ri} t_h} \quad (\text{E.3-14})$$

where

C_{wvi}	=	concentration of i^{th} contaminant in plants as a result of irrigating plants with contaminated water (pCi/g, rad) (mg/kg, chem)
λ_w	=	effective depletion constant of i^{th} contaminant on the surface plants also known as the weathering removal rate (h^{-1})
λ_{ri}	=	radioactive or chemical decay constant of i^{th} contaminant (h^{-1})
λ_{di}	=	soil depletion constant (h^{-1})
$B_{iv(2)}$	=	dry soil to wet plant partitioning coefficient of i^{th} contaminant (C_{iv}/C_s)
d_w	=	irrigation deposition rate (pCi/m ² -h, rad) (mg/m ² -h, chem)
f_w	=	fraction of year plant is irrigated (unitless)
ρ	=	effective dry surface density of the soil (g/m ² , rad) (kg/m ² , chem)
r_w	=	fraction of water borne material retained on plant surface (unitless)
t	=	growing season (h)
t_{bw}	=	duration of irrigation use (h)
t_h	=	duration of period between harvest and consumption (h)
Y	=	agricultural yield (g/m ² , rad) (kg/m ² , chem)

The soil depletion coefficient is calculated by

$$\lambda_d = \lambda_n + \lambda_{Li} \quad (\text{E.3-15})$$

where the leaching coefficient (λ_{Li}) is calculated using the relationship (Baes and Sharp 1983):

$$\lambda_L = \frac{V_w}{z \theta \left[1 + \frac{K_d}{\theta} \right]}$$

(E.3-16)

and where

- λ = Leach rate (h^{-1})
 V_w = Percolation rate (nominally 0.0044 cm/h through Pits and 2)
 z = Depth of surface soil (15 cm)
 δ = Density of soil in root zone (nominally 1.5 g/cm^3)
 K_d = Water to soil partitioning coefficient (cm^3/g)
 θ = Moisture fraction of surface soil (measured at 0.17)

Vegetables Contaminated by Aerial Deposition

Eating vegetables and fruit contaminated by aerial deposition of contaminated dust can contribute to the total intake of contaminants by humans. If measured concentrations in the plants are not available (e.g. future exposures), this concentration is estimated using Equation 7-10 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992a). The equation used to estimate contaminant concentrations in vegetation is:

$$C_{avi} = d_d \left[\frac{r_d(1 - e^{-\lambda_w t_e})}{Y\lambda_w} + \frac{f_d B_{iv(2)} CF_p (1 - e^{-\lambda_{di} t_{bd}})}{\rho \lambda_{di}} \right] e^{-\lambda_{ri} t_h} \quad (\text{E.3-17})$$

where

- C_{avi} = concentration of the i^{th} contaminant in/on vegetables and fruit (pCi/g , rad)(mg/kg , chem)
 λ_w = effective depletion constant of i^{th} contaminant on the surface plants, also known as the weathering rate (h^{-1})
 λ_{di} = soil depletion constant (hr^{-1})
 λ_{ri} = radioactive or chemical decay constant of i^{th} contaminant (h^{-1})
 $B_{iv(2)}$ = dry soil to wet plant partitioning coefficient of i^{th} contaminant (C_{iv}/C_s)
 CF_p = dry to wet weight conversion factor (0.428, food crops) (1.0, feed and forage)
 C_{vdi} = concentration of i^{th} contaminant in plants as a result of dust deposition on plants and surrounding soil (pCi/g , rad) (mg/g , chem)
 d_d = constituent's deposition rate ($\text{pCi}/\text{m}^2\text{-h}$, rad) ($\text{mg}/\text{m}^2\text{-h}$, chem)
 f_d = fraction of year plant is down wind (unitless)
 r_d = fraction of airborne material retained on plant surface (unitless)
 t_e = growing season (h)
 t_{bd} = duration soil is exposed to airborne emissions (h)

- t_h = duration of period between harvest and consumption (h); and
 Y = agricultural yield (g/m^2 , rad) (kg/m^2 , chem)
 ρ = effective dry surface soil density (g/m^2 , rad) (kg/m^2 , chem)

Equations 7-5 and 7-6 from DOE 1992 are used to quantify intake from the crop ingestion pathway:

$$\text{(radionuclides)} \quad I_{avi} = (C_{avi})(IR)(FI)(EF)(ED) \quad (\text{E.3-18})$$

$$\text{(chemicals)} \quad I_{avi} = (C_{avi})(IR)(FI)(EF)(ED)/(BW)(AT) \quad (\text{E.3-19})$$

where

- I_{avi} = intake from vegetation (pCi, rad) (mg/kg-d, chem)
 C_{avi} = total concentration of contaminants in vegetable (pCi/g, rad) (mg/kg, chem)
 IR = ingestion rate (g/d, rad) (kg/d, chem)
 FI = fraction ingested from contaminated source (unitless)
 EF = exposure frequency (d/y)
 ED = exposure duration (y)
 BW = body weight (kg)
 AT = averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)

E.3.5.4.2 Beef Ingestion

Beef (and milk) can become contaminated in three ways at this facility. The first way is through use of contaminated water as stock water. The second is by aerial deposition of contaminants on feed crops or forage, and the third is by direct ingestion of soil while grazing.

Beef and Dairy Products Produced with Contaminated Stock Water

This scenario assumes that water is used for stock water and irrigation of feed. Animals drinking the water ingest contaminants directly. Plants irrigated with water take up constituents via root uptake, and direct deposition onto exposed surfaces by irrigation water. If measured values are not available (e.g., future exposures), this concentration can be calculated using the methodology set forth in the FEMP Risk Assessment Work Plan Addendum (DOE 1992a). The concentration of a contaminant in animal products, such as beef or milk, is estimated using the following equation:

$$C_{Ai} = F_{Ai}[(C_{fi})(Q_f) + (C_{wi})(Q_w)] e^{-\lambda_{eff} t_h} \quad (\text{E.3-20})$$

where

- C_{Ai} = concentration of i^{th} contaminant in the animal product (pCi/L for milk, pCi/g for beef, rad) (mg/L for milk, mg/kg for beef, chem)
 C_{fi} = concentration of i^{th} contaminant in feed (pCi/g, rad) (mg/kg, chem)
 C_{wi} = concentration of contaminant in water (pCi/L, rad) (mg/L, chem)
 F_{Ai} = element (stable) transfer coefficient that relates the daily intake by an animal to the concentration of i^{th} contaminant in an edible portion of the animal product (d/L for milk, d/g for meat)

- Q_f = consumption rate of contaminated feed by livestock (g/d, rad) (kg/day, chem)
 Q_w = consumption rate of contaminated stock water by livestock (L/d)
 λ_{ri} = radioactive or chemical decay constant of i^{th} contaminant (h^{-1})
 t_h = duration of period between harvest and consumption (h)

Meat or Milk Downwind of Source

Forage, feed, and soils downwind of a potential source of contaminated dust can have contamination deposited on them by settling dust. Ingestion of these plants by livestock contributes to the body burden of these contaminants in livestock. Consumption of meat or milk from these animals contributes to the total intake of these contaminants by humans. The magnitude of the contaminant exposure by humans depends, in part, on the concentration of the constituent in the animal products. If measured values are not available (e.g. future exposures), this concentration can be calculated using the methodology set forth in the FEMP Risk Assessment Work Plan Addendum (DOE 1992a). The concentration of a contaminant in animal products, such as beef or milk, is estimated using the following equation:

$$C_{Ai} = F_{Ai} [(C_{afi})(Q_f) + (C_{agi})(Q_g) + (C_{asi})(Q_s)] e^{-\lambda_{ri} t_h} \quad (\text{E.3-21})$$

where

- C_{Ai} = concentration of i^{th} contaminant in the animal product (pCi/L for milk, pCi/g for beef, rad) (mg/L for milk, mg/kg for beef, chem)
 C_{afi} = concentration of i^{th} contaminant in feed (pCi/g, rad) (mg/kg, chem)
 C_{agi} = concentration of i^{th} contaminant in forage (pCi/g, rad) (mg/kg, chem)
 C_{asi} = concentration of i^{th} contaminant in soil (pCi/g, rad) (mg/kg, chem)
 F_{Ai} = elemental transfer coefficient that relates the daily intake by an animal to the concentration of i^{th} contaminant in an edible portion of the animal product (d/L for milk, d/g for meat)
 Q_f = consumption rate of contaminated feed by livestock (g/d, rad) (kg/day, chem)
 Q_g = consumption rate of contaminated forage by livestock (g/d, rad) (kg/day, chem)
 Q_s = consumption rate of contaminated soil by livestock (g/d, rad) (kg/day, chem)
 λ_{ri} = radioactive or chemical decay constant of i^{th} contaminant (h^{-1})
 t_h = duration of period between harvest and consumption (h)

If measured values for the concentrations of constituents in stored feed are not available (e.g. future exposures), this concentration is estimated using Equation 7-9 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992a). The equation is:

$$C_{vwi} = d_d \left[\frac{r_d (1 - e^{-\lambda_{wi} t_e})}{Y \lambda_w} + \frac{f_d B_{iv(1)} C F_p (1 - e^{-\lambda_{di} t_{bw}})}{\rho \lambda_{di}} \right] e^{-\lambda_{ri} t_h} \quad (\text{E.3-22})$$

where

C_{vwi}	= concentration of i^{th} contaminant in plants as a result of irrigating plants with contaminated water (pCi/g, rad) (mg/kg, chem)	2
λ_{ri}	= radioactive or chemical decay constant of i^{th} contaminant (h^{-1})	3
λ_w	= effective depletion constant of i^{th} contaminant on the surface plants also known as the weathering removal rate (h^{-1})	4
λ_{di}	= soil depletion constant (hr^{-1})	5
$B_{iv(1)}$	= dry soil to wet plant partitioning coefficient of i^{th} contaminant (C_{iv}/C_s)	6
CF_p	= dry to wet weight conversion factor (0.428, food crops) (1.0, feed and forage)	7
d_d	= deposition rate (pCi/ m^2 -h, rad) (mg/ m^2 -h, chem)	8
f_d	= fraction of year plant is downwind (unitless)	9
ρ	= effective dry surface density of the soil (g/m^2 , rad) (kg/m^2 , chem)	10
r_d	= fraction of airborne material retained on plant surface (unitless)	11
t_e	= growing season (h)	12
t_{bw}	= duration of irrigation use (h)	13
t_h	= duration of period between harvest and consumption (h)	14
Y	= agricultural yield (g/m^2 , rad) (kg/m^2 , chem)	15

The amount of a contaminant a receptor takes in as a result of consuming beef is determined using the concentration of a chemical in the animal's flesh. Equations 7-17 and 7-18 from DOE 1992a are used to quantify intake from eating beef:

$$\text{(radionuclides)} \quad I_{Ai} = (C_{Ai})(IR)(FI)(EF)(ED) \quad (\text{E.3-23})$$

$$\text{(chemicals)} \quad I_{Ai} = (C_{Ai})(IR)(FI)(EF)(ED)/(BW)(AT) \quad (\text{E.3-24})$$

where

I_{Ai}	= intake of i^{th} constituent from beef (pCi, rad) (mg/kg-d, chem)	24
C_{Ai}	= concentration of i^{th} contaminant in animal product (pCi/g, rad) (mg/kg, chem)	25
IR	= ingestion rate (g/d, rad) (kg/d, chem)	26
FI	= fraction ingested from contaminated source (unitless)	27
EF	= exposure frequency (d/y)	28
ED	= exposure duration (y)	29
BW	= body weight (kg)	30
AT	= averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)	31

E.3.5.4.3 Milk Consumption

The amount of a contaminant a receptor takes in as a result of consuming dairy products is determined using the concentration of a chemical in the animal's milk. Equations 7-17 and 7-18 from DOE 1992a are used to quantify intake from consuming dairy products:

$$\text{(radionuclides)} \quad I_{Ai} = (C_{Ai})(IR)(FI)(EF)(ED) \quad (\text{E.3-25})$$

$$\text{(chemicals)} \quad I_{Ai} = (C_{Ai})(IR)(FI)(EF)(ED)/(BW)(AT) \quad (\text{E.3-26})$$

where

- I_{Ai} = intake of i^{th} constituent from dairy products (pCi, rad) (mg/kg-d, chem)
 C_{Ai} = concentration of i^{th} contaminant in animal product (pCi/L, rad) (mg/L, chem)
 IR = ingestion rate (L/d)
 FI = fraction ingested from contaminated source (unitless)
 EF = exposure frequency (d/y)
 ED = exposure duration (y)
 BW = body weight (kg)
 AT = averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)

E.3.5.4.4 Fish Ingestion

If measured concentrations of a constituent in fish are unknown, they are estimated using Equation 7-19 of the FEMP Risk Assessment Work Plan Addendum (DOE 1992a):

$$C_{Fi} = (C_{wi})(BCF_{Fi}) e^{-\lambda_i t_h} \quad (\text{E.3-27})$$

where

- C_{Fi} = concentration of the i^{th} constituent in fish (pCi/g, rad) (mg/kg, chem)
 C_{wi} = concentration of the i^{th} constituent in surface water (pCi/L, rad) (mg/L, chem)
 BCF_{Fi} = fish bioconcentration factor (pCi/g fish per pCi/L, rad) (mg/kg fish per mg/L, chem)
 λ_i = radioactive or chemical decay constant of i^{th} contaminant (h^{-1})
 t_h = duration of period between harvest and consumption (h)

The amount of a contaminant a receptor takes in as a result of consuming local fish on a regular basis is determined by using the concentration of a chemical in the fish's flesh. Equations 7-17 and 7-18 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992a) are used to quantify intake from consuming fish:

$$(\text{radionuclides}) \quad I_{Fi} = (C_{Fi})(IR)(FI)(EF)(ED) \quad (\text{E.3-28})$$

$$(\text{chemicals}) \quad I_{Fi} = (C_{Fi})(IR)(FI)(EF)(ED)/(BW)(AT) \quad (\text{E.3-29})$$

where

- I_{Fi} = intake of i^{th} constituent from fish (pCi, rad) (mg/kg-d, chem)
 C_{Fi} = concentration of i^{th} contaminant in fish (pCi/g, rad) (mg/kg, chem)
 IR = ingestion rate (g/d, rad) (kg/d, chem)
 FI = fraction ingested from contaminated source (unitless)
 EF = exposure frequency (d/y)
 ED = exposure duration (y)
 BW = body weight (kg)
 AT = averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)

E.3.5.5 Indoor Radon Exposures

A resident living on soil or waste containing radium may incur exposures to radon entering their dwelling from the soil or waste beneath the structure. These risks must be considered along with risks from other sources when evaluating risks to a receptor living within Operable Unit 1.

This study evaluates risks from radon exposures to a resident occupying a home located on top of a pit containing buried waste. The conceptual model selected for this risk assessment assumes a home is built over Pit 4, which is the most stable pit in Operable Unit 1. The home is assumed to be 3 m high, 20 m long and 10 m wide. The home is assumed to have an air exchange rate of 0.1 h^{-1} , which is characteristic of a tightly sealed, energy efficient home (Nero et al 1983).

It is likely that any house located over a waste pit would use slab-on-grade construction. Anyone excavating a basement for a house located over one of the Operable Unit 1 waste pits would soon discover they were digging in a waste disposal site. These people would probably leave to build their house elsewhere after digging into the waste, because few people would willingly choose to take up permanent residence over a waste pit. People using slab-on-grade construction while building their home may avoid digging into the waste and so remain unaware of their location relative to the buried waste.

The concrete slab beneath the hypothetical home is nominally 15 cm thick, and the permeability of the concrete is assumed to be equal to the soils beneath it. This is very conservative, because the permeability of concrete to gas movement is normally several factors of ten lower than that of soil.

This analysis assumes the fluence rate of radon entering the home through the concrete slab equals the radon fluence rate emanating from the vent pipe penetrating the clay cap over Pit 4. This is also a conservative assumption, because radon entering a slab-on-grade home would normally first have to move through the clay cap, allowing time for radioactive decay to decrease the radon fluence rate. Using data from the pipe neglects the impact of this delay time.

The fluence rate expressed as the radiological activity due to radon emanating from a square meter of soil in 1 second from the vent pipe was measured for three days over a five day period (Appendix C.1). The maximum measured fluence rates from these pipes was $0.005 \text{ pCi/m}^2/\text{s}$. This fluence rate is supported by process knowledge of the pit which indicates that no radium was buried there. The only source of radium would be as a result of decay from the uranium and thorium disposed there. Due to the long half-lives of these nuclides, no appreciable concentrations of radium are expected to be produced in the pit during the 1000-year study period. Therefore radon flux from the pit should remain low at the measured levels.

Using this conceptual model, and the radon fluence rate of 0.005 pCi/m²/s, radon levels in the home attributable to the radon sources beneath the structure are calculated from the following equation, as adapted from Nero, et al., 1983:

$$C_{Rn} = \frac{(J_{Rn}) (A_s) (CF) [1 - e^{-(\lambda_{Rn} + \lambda_{Vent}) t}]}{(\lambda_{Rn} + \lambda_{Vent}) (V_{Home})} \quad (E.3-30)$$

where

C_{Rn}	=	Concentration of radon in indoor air (pCi·L ⁻¹)
J_{Rn}	=	Radon fluence rate (pCi·m ⁻² ·s ⁻¹)
A_s	=	Surface area under structure (m ²)
CF	=	Unit conversion factor (3.6 s·m ³ ·h ⁻¹ ·L ⁻¹)
λ_{Rn}	=	Radioactive decay coefficient of Rn-222 (h ⁻¹)
λ_{Vent}	=	Ventilation depletion coefficient of Rn-222 (h ⁻¹)
t	=	Time to equilibrium (h)
V_{Home}	=	Volume of home (m ³)

Radon air concentrations in the home are calculated to be approximately 0.06 pCi/L.

Intakes of radon are calculated using Equation E.3-12. Using this methodology, the total intake is directly proportional to the exposure concentration and the total volume inhaled. If the concentration is held constant, the intake is related to the inhalation rate and the total time spent breathing the indoor air over a lifetime. Based on these criteria, the resident farmer is selected as the RME receptor for indoor radon exposures.

Using Equation E.3-12, a RME resident farmer breathing indoor air containing 0.06 pCi/L at a rate of 15 m/d (EPA 1991f) for 350 d/y would inhale 16,500 pCi of radon during a 70 year lifetime. Risks associated with this exposure are presented in Section E.5.3.3.1.

E.3.5.6 Quantification of Intakes and Exposures from Multiple Pathways

The most probable scenarios involve simultaneous exposures via a number of pathways. The multiple exposure scenarios are evaluated by assuming the contributions from component pathways are cumulative. Thus, all the receptors evaluated are subject to more than one exposure pathway and have been evaluated accordingly.

E.3.5.7 Scenario-Specific Assumptions and Exposure Parameters

Exposure parameters are dependent on receptor-specific behavior patterns, and vary from receptor scenario to receptor scenario. The following sections begin with a brief description of each set of parameters used to evaluate exposures to hypothetical receptors during this assessment. This synopsis is followed by descriptions of any site-specific parameter values and their derivation. Tables E.3-16 and E.3-17 contain a summary of these parameters.

E.3.5.7.1 Exposure Duration (ED)

The exposure duration is the period of time a receptor is exposed in a lifetime. Tables E.3-16 and E.3-17 list the values and sources of the exposure durations used to calculate exposures to the hypothetical receptors evaluated in this assessment.

Because of the agricultural history of the area, the RME adult may be exposed over an entire 70-year lifetime. Therefore, the exposure duration selected for this receptor is 70 years. This value is over twice as long as the standard 30-year exposure presented in EPA 1991b. The 70-year value was determined in consultation with EPA Region V and applies to the off-property RME resident adult farmer, the on-property RME resident adult farmer, the Great Miami River user, and the off-property user of beef and dairy products.

The RME child and the CT adult are assumed to receive exposures over 6 years and 9 years, respectively, as suggested by supplemental guidance (EPA 1991b). The trespassing child is assumed to receive exposures while roaming randomly about the property between the ages of six and 18. EPA Region V requires this activity to be evaluated over an exposure duration of 12 years. The on-property visitor is assumed to visit the site for 25 years. The home builder is evaluated to assess the health impacts of exposures incurred while building a home on the property. This activity is assumed to be completed within one year of groundbreaking (NRC 1984), so the exposure duration for the home builder is set at one year.

The Great Miami River user is also assumed to swim in the river. Strong currents in this river would likely prevent very young or old swimmers from engaging in this activity. It is assumed that this receptor only swims during a 30-year period of the individual's life. Therefore, the exposure duration for this scenario is 30 years.

E.3.5.7.2 Exposure Frequency

The exposure frequency is the number of days a receptor is exposed each year. Tables E.3-16 and E.3-17 list the values and sources of the exposure frequencies used to calculate exposures to the hypothetical receptors evaluated in this assessment.

The exposure frequency selected for scenarios involving a RME adult farmer or a RME child is the standard RME value of 350 days per year listed in EPA 1989a. The 350 days per year value applies to the off-property RME resident adult, the on-property RME resident adult, the on-property RME resident child, the Great Miami River user, and the off-property user of beef and dairy products. The on-property visitor is assumed to visit the site 250 days per year (EPA 1991a).

The exposure frequency selected for scenarios involving a CT adult farmer is 275 days per year, as suggested by supplemental guidance (EPA 1991b). EPA Region V requires the exposure frequency of the trespassing child to be set at 52 days per year.

The home builder is evaluated to assess the health impacts of exposures incurring while building a home on the property. This activity is assumed to be completed after 500 hours. (NRC 1984). Assuming a worker spends 10 hours per day during construction, the exposure frequency for the home builder is 50 days per year.

The Great Miami River user is assumed to swim in the river. The exposure frequency selected for this activity is five days per year averaged over a lifetime, as suggested by guidance (EPA 1989a).

E.3.5.7.3 Exposure Time

The exposure time is the amount of time a receptor is exposed each day. Tables E.3-16 and E.3-17 list the values and sources of the exposure times used to calculate exposures to the hypothetical receptors evaluated in this assessment.

The RME adult farmer scenarios constructed for this assessment assume the receptor works outside of the residence for 2000 hours per year. Spreading this time over the 350 days per year of on-site exposure yields an average outdoor exposure time of 5.7 hours per day. This leaves an indoor exposure time of 18.3 hours per day for this receptor. Thus, about 25 percent of the receptor's time on-site is spent outside of the residence. These values apply to the off-property RME resident adult farmer and the on-property RME resident adult farmer. The on-property RME resident child is assumed to spend only 2 hours per day outdoors, for a total of 700 hours per year.

EPA Region V assumes the CT resident adult farmer is exposed outdoors for 48 days out of the 275 days spent on a site. This is equivalent to an exposure time of 4.2 hours per day. This leaves an indoor exposure time of 19.8 hours per day for this receptor. Thus, about 20 percent of the receptor's time on-site is spent outside of the residence. These values apply only to the CT receptor.

The trespassing child is assumed to spend time on the site. Current trespassing activities are minimal because Operable Unit 1 is currently surrounded by two fences and patrolled on a regular basis by a security force. If these patrols are relaxed, trespassing may occur, but the time spent on the property is unknown. EPA Region V requires the exposure time of the trespassing child to be set at 4 hours per day if site-specific information is not available. The on-property visitor is assumed to spend 2 hours per day outdoors on the site.

The home builder is evaluated to assess the health impacts of exposures incurring while building a home on the property. This activity is assumed to be completed after 500 hours (NRC 1984).

Assuming a worker constructs a house in 50 days, the total exposure time for the home builder is 10 hours per day. This time is divided equally into 5 hours per day outside of the structure and 5 hours per day inside of the structure.

The RME adult farmer and child receptors are assumed to receive skin exposures via bathing or showering once a day. Since no site-specific information on this activity is available, the adult exposure time selected for this activity is 0.25 hours per day, as suggested by guidance (EPA 1989a). The exposure time selected for the RME child performing this activity is 0.25 hour per day, as suggested by guidance (EPA 1992e).

The Great Miami River user is assumed to use the river for recreational swimming. Since no site-specific information on this activity is available, the exposure time selected for this activity is 0.2 hour per day, 5 days per year, as suggested by guidance (EPA 1992e).

E.3.5.7.4 Inhalation Rates

The inhalation rate is the volume of air inhaled daily by a receptor. Tables E.3-16 and E.3-17 list the values and sources of the inhalation rates used to calculate exposures to the hypothetical receptors evaluated in this assessment.

EPA suggests using a value of 20 cubic meters per day ($0.83 \text{ m}^3/\text{h}$) as the inhalation rate for an RME adult (EPA 1989b). Due to a lack of information, this inhalation rate is used for the trespassing child and all adult exposures, except those involving inhalation of volatiles and radon within the home and the visitor exposures. Inhalation of volatiles from water and radon in the home is evaluated using 15 cubic meters per day for the 18.3 h/d the receptor is inside ($0.82 \text{ m}^3/\text{h}$), as presented (EPA 1991f). EPA Region V has requested that $2.0 \text{ m}^3/\text{h}$ be used as the inhalation rate for a visitor. The inhalation rate for the on-property RME child was set at $0.5 \text{ m}^3/\text{h}$, given the child's smaller lung capacity and time spent at rest.

E.3.5.7.5 Soil Ingestion Rates

The soil ingestion rate is the mass of soil ingested daily by a receptor. Tables E.3-16 and E.3-17 list the values and sources of the soil ingestion rates used to calculate exposures to the hypothetical receptors evaluated in this assessment.

The soil ingestion rate of the RME adult farmer estimated for this risk assessment is a site-specific time weighted average ingestion rate. It is based on ingestion rates for specific activities performed during the course of the receptor's lifetime, and the relative length of time spent engaged in those activities.

4287

The first six years of the RME adult's life are spent as a young child whose ingestion rate is 0.2 grams per day. Using EPA's suggested exposure frequency of 350 days per year, this period contributes a total of 420 grams of soil to the lifetime total.

Between the ages of 18 and 70, the RME adult farmer is assumed to spend about 50 years working a farm. The 1987 Census of Agriculture (DOC, 1987) indicates that 1,284 of the 1,364 farms in Hamilton and Butler Counties (95 percent) are under 500 acres. Assuming a farmer follows recommended agricultural practices and rotates his crops, a typical farm may have 35 percent of its available acreage in corn, 35 percent in soybeans, 20 percent in wheat, and 10 percent in hay. The U.S. Soil Conservation Service Field Office Technical Guide indicates that farmers spend 1.24 hour per acre farming corn, 1 hour per acre farming soybeans, 1.28 hours per acre farming wheat, and 2.73 hours an acre farming hay. From this information, it is calculated that 95 percent of the farmers in Hamilton County spend less than 660 hours per year actually farming the land. An additional 20 percent is added to the 660 hours to account for breakdowns, walkover surveys, and miscellaneous activities, raising the total time to just under 800 hours per year. Assuming the farmer works for eight hours per day, the farmer spends 100 days per year actually farming. EPA suggests using an incidental soil ingestion rate during farming activities of 0.48 grams per day, so the amount of soil ingested over the 50-year occupational lifetime of a farmer would be 2,400 grams. In the remaining 250 days a year spent on the property during these 50 years, the resident ingests soil at a rate of 0.1 grams per day — adding another 1,259 grams of soil to the farmer's diet. The remaining fourteen years of the receptor's life are spent as an older child (12 years) and an adult (2 years) whose ingestion rates are 0.1 grams per day, contributing another of 490 grams of soil to the lifetime total. The combined intake from all periods in the RME adult resident's life is 4,560 grams of soil or about 0.18 grams per day. The 0.18 grams per day value is used to quantify the exposures due to incidental ingestion of soil by the RME adult in this assessment, which differs from the value presented in the Work Plan Addendum (DOE 1992a).

The soil ingestion rates for the trespassing child (0.1g/day) and the on-property resident child (0.2g/day) were specified by DOE (1992a). The soil ingestion rates for the CT on-property farmer (0.122g/day) and the on-property home builder (0.48g/day) were provided by EPA Region V.

It was assumed that all on-property receptors received 100 percent of their soil intake from the site. This includes the on-property RME child and adult, the on-property CT adult, and the home builder. The trespassing child was assumed to only receive 25 percent of his daily soil intake from the site, as only 4 of 16 waking hours are spent on property.

E.3.5.7.6 Water Ingestion Rates

The water ingestion rate is the volume of water drunk daily by a receptor. Generally this intake is from drinking water, but may be from incidental ingestion during swimming. Tables E.3-16 and

E.3-17 list the values and sources of the water ingestion rates used to calculate exposures to the hypothetical receptors evaluated in this assessment.

This assessment uses a drinking water ingestion rate of 2 liters per day for the RME adult receptors and 1.4 liters per day for the RME child, as stipulated in EPA 1989a. EPA Region V suggests assuming that the CT adult drinks 1.4 liters per day.

The hypothetical Great Miami River user accidentally ingests water while swimming in the river. The ingestion rate of this receptor is 0.05 liters per hour (EPA 1992e).

E.3.5.7.7 Food Consumption

Some of the hypothetical receptors evaluated consume vegetables, fruit, beef, and dairy products grown on-property. Tables E.3-16 and E.3-17 list the values and sources of the food consumption rates used to calculate exposures to the hypothetical receptors evaluated in this assessment.

The hypothetical RME adult farmer eats 80 grams per day of vegetables, 42 grams per day of fruit, and 75 grams of beef per day from home-grown sources. The RME adult consumes home-grown dairy products such as milk and cheese at the rate of 0.3 liters per day (EPA 1989a).

Discussions with EPA Region V are the sources of parameter values for the hypothetical CT adult farmer. This receptor eats 50 grams per day of vegetables, 28 grams per day of fruit, and 50 grams of beef per day from home-grown sources. The RME adult farmer consumes home-grown dairy products such as milk and cheese at the rate of 0.3 liters per day (DOE 1992a), while the CT adult farmer was assigned a value of 0.2 liters per day, as per EPA Region V guidance.

There is no EPA guidance on food ingestion rates for children at this time. The values used in this assessment were derived during the development of the Work Plan Addendum (DOE (1992a) and are based on work performed by the U.S. Department of Agriculture (USDA 1986). The hypothetical RME child eats 40 grams per day of vegetables, 61.5 grams per day of fruit, and 29 grams of beef per day. The RME child consumes dairy products such as milk and cheese at the rate of 0.9 liters per day.

E.3.5.7.8 Body Weights

The body weight is the mass of the receptor, in kilograms. This assessment uses the median body weight of 70 kilograms for all adult receptors, 43 kilograms for all older children and 15 kilograms for all young children, as stipulated in the Work Plan Addendum (DOE 1992a). Tables E.3-16 and E.3-17 list the values and sources of the body weights used to calculate exposures to the hypothetical receptors evaluated in this assessment.

E.3.5.7.9 Surface Areas

The surface area is the amount of the body's skin surface which is exposed as a result of a specific activity or group of activities. Tables E.3-16 and E.3-17 list the values and sources of the surface areas used to calculate exposures to the hypothetical receptors evaluated in this assessment.

EPA's interim report on dermal assessment (EPA 1992a) and supplemental guidance on dermal assessment (EPA 1992i) lists suggested values for surface areas. The surface areas used to evaluate exposures from dermal contact while bathing and swimming in this assessment are 2.0 square meters for all adult receptors, and 0.72 square meters for children. These values differ from those presented in the Work Plan Addendum, which predated the dermal guidance.

It was assumed that 25 percent of a receptor's total body surface area is accounted for by the hands, legs, arms, neck, and head, allowing for clothing (EPA 1992a). This factor results in exposed skin surface areas of 0.38 m² for the trespassing child 0.5 m² for adults, and 0.18 m² for the RME child. Again, these values differ from those presented in the Work Plan Addendum.

E.3.5.7.10 Adherence Factors

Uptake of chemicals through the skin from soil require that a sufficiently intimate intake be established between the soil and the skin. One of the factors that determine the quantity of chemical absorbed is the amount of soil that adheres to the skin. Tables E.3-16 and E.3-17 list the soil adherence values and sources used to estimate dermal uptake from soil. Following the suggestion of EPA (1992e), a factor of 1.0 mg/cm² is used for all RME evaluations and 0.2 is used for the CT adult farmer.

E.3.5.7.11 Averaging Times

The averaging time is the duration of time, expressed in days, over which the period of exposure occurs. It is only used in the evaluation of chemical exposures. The averaging time selected depends on the health effect being evaluated. Long-term intakes of noncarcinogenic agents are calculated by averaging intakes over the period of exposure, as per EPA guidance (EPA 1989a). Carcinogenic intakes are averaged over the lifetime of the receptor. This approach is based on the contention that a high dose administered over a short period is equivalent to a low dose over a long period. Tables E.3-16 and E.3-17 list the values and sources of the averaging times used to calculate exposures to the hypothetical receptors evaluated in this assessment.

E.3.6 SUMMARY OF EXPOSURE ASSESSMENT

This exposure assessment evaluates the types and magnitudes of contact that a potential receptor may have with site-related constituents. A conceptual model for Operable Unit 1 has been developed to provide the basis for identifying and evaluating the potential risks to human health in this baseline risk assessment. The conceptual model served as framework for identifying the paths by which human health may be impacted by Operable Unit 1.

The materials in eight waste pits were treated as the primary sources of potential contamination in Operable Unit 1. These waste pits contain both chemical and radioactive constituents which can be released by a variety of mechanisms including leaching to groundwater, erosion by surface water and air, and human intrusion. The potential for these contaminants to be transported by groundwater, surface water, and air after their release is estimated in this assessment using mathematical models which attempt to quantify natural transport phenomena.

The potential for human exposures is also investigated. Particular emphasis is placed on identifying applicable receptors and exposure routes.

TABLE E.3-1

**SUMMARY OF EXPOSURE PATHWAYS QUANTITATIVELY EVALUATED IN RISK ASSESSMENT
CURRENT SOURCE TERM**

Scenario/Receptor	Soil/Pit Contents	Air	Surface Water
Current Land Use With Active Access Controls			
Off-Property RME Farmer	NA*	<ul style="list-style-type: none"> • Inhalation of VOCs, radon, and particulates • Ingestion of vegetables and fruit • Ingestion of meat and dairy products 	NA
Visitor	<ul style="list-style-type: none"> • Direct radiation 	<ul style="list-style-type: none"> • Inhalation of VOCs, radon, and particulates 	NA
Current Land Use Without Access Controls			
Off-Property RME Farmer	NA	<ul style="list-style-type: none"> • Inhalation of VOCs, radon, and particulates • Ingestion of vegetables and fruit • Ingestion of meat and dairy products 	NA
Trespassing Child	<ul style="list-style-type: none"> • Incidental ingestion of surface soil • Dermal contact with surface soil • Direct radiation 	<ul style="list-style-type: none"> • Inhalation of VOCs, radon, and particulates 	NA
Off-Property User of Meat and Dairy Products	<ul style="list-style-type: none"> • Ingestion of meat and dairy products 	NA	<ul style="list-style-type: none"> • Ingestion of meat and dairy products
*NA - Not Applicable			

TABLE E.3-2

**SUMMARY OF EXPOSURE PATHWAYS QUANTITATIVELY EVALUATED IN RISK ASSESSMENT
FUTURE SOURCE TERM**

4282

Scenario/ Receptor	Soil/Pit Contents	Air	Groundwater	Surface Water	Sediment
Current Land Use Without Access Controls					
Off-Property RME Resident Farmer	NA ^a	<ul style="list-style-type: none"> • Inhalation of VOCs, radon, and particulates • Ingestion of vegetables and fruit • Ingestion of meat and dairy products 	<ul style="list-style-type: none"> • Ingestion of drinking water • Inhalation of VOCs and radon • Dermal contact while bathing • Ingestion of vegetables and fruit • Ingestion of meat and dairy products 	NA	NA
Trespassing Child	<ul style="list-style-type: none"> • Incidental ingestion of surface soil (Pits 1, 2, 4, Burn) • Dermal contact with surface soil (Pits 1, 2, 4, Burn) • Incidental ingestion of pit material (Pits 3, 5, 6) • Dermal contact with pit material (Pits 3, 5, 6) • Direct radiation 	<ul style="list-style-type: none"> • Inhalation of VOCs, radon, and particulates 	NA	NA	<ul style="list-style-type: none"> • Incidental ingestion of sediment (Paddys Run) • Dermal contact with sediment (Paddys Run) • Direct radiation

E-3-59

0510

TABLE E.3-2
(Continued)

Scenario/ Receptor	Soil/Pit Contents	Air	Groundwater	Surface Water	Sediment
Great Miami River User	NA	NA	NA	<ul style="list-style-type: none"> • Incidental ingestion while swimming • Dermal contact while swimming • Drinking water ingestion • Inhalation of VOCs and radon • Dermal contact while bathing • Ingestion of vegetables and fruit • Ingestion of meat and dairy products • Ingestion of fish 	NA
Off-Property User of Meat and Dairy Products	<ul style="list-style-type: none"> • Ingestion of meat and dairy products (Pits 1, 2) 	NA	NA	<ul style="list-style-type: none"> • Ingestion of meat and dairy products (Pits 5, 6) 	NA

4282

TABLE E.3-2
(Continued)

Scenario/ Receptor	Soil/Pit Contents	Air	Groundwater	Surface Water	Sediment
Future Land Use					
On-Property RME Resident Farmer	<ul style="list-style-type: none"> • Incidental ingestion of surface soil (Pits 1, 2, 4, Burn) • Dermal contact with surface soil (Pits 1, 2, 4, Burn) • Incidental ingestion of pit material (Pits 3, 5, 6) • Dermal contact with pit material (Pits 3, 5, 6) • Direct radiation • Ingestion of vegetables and fruit (Pits 1, 2) • Ingestion of meat and dairy products (Pits 1, 2) 	<ul style="list-style-type: none"> • Inhalation of VOCs, radon, and particulates • Ingestion of vegetables and fruit • Ingestion of meat and dairy products 	<ul style="list-style-type: none"> • Ingestion of drinking water • Dermal contact while bathing • Inhalation of volatiles and radon while showering • Ingestion of vegetables and fruit • Ingestion of meat and dairy products 	<ul style="list-style-type: none"> • Ingestion of meat and dairy products 	<ul style="list-style-type: none"> • Incidental ingestion of sediment • Dermal contact with sediment

E-3-61

0512

TABLE E.3-2
(Continued)

Scenario/ Receptor	Soil/Pit Contents	Air	Groundwater	Surface Water	Sediment
On-Property CT Resident Farmer	<ul style="list-style-type: none"> • Incidental ingestion of surface soil (Pits 1, 2, 4, Burn) • Dermal contact with surface soil (Pits 1, 2, 4, Burn) • Incidental ingestion of pit material (Pits 3, 5, 6) • Dermal contact with pit material (Pits 3, 5, 6) • Direct radiation • Ingestion of vegetables and fruit (Pits 1, 2) • Ingestion of meat and dairy products (Pits 1, 2) 	<ul style="list-style-type: none"> • Inhalation of VOCs, radon, and particulates • Ingestion of vegetables and fruit • Ingestion of meat and dairy products 	<ul style="list-style-type: none"> • Ingestion of drinking water • Dermal contact while bathing • Inhalation of volatiles and radon while showering • Ingestion of vegetables and fruit • Ingestion of meat and dairy products 	<ul style="list-style-type: none"> • Ingestion of meat and dairy products 	<ul style="list-style-type: none"> • Incidental ingestion of sediment • Dermal contact with sediment

E-3-62 0513

TABLE E.3-2
(Continued)

Scenario/ Receptor	Soil/Pit Contents	Air	Groundwater	Surface Water	Sediment
On-Property RME Child	<ul style="list-style-type: none"> Incidental ingestion of surface soil (Pits 1, 2, 4, Burn) Dermal contact with surface soil (Pits 1, 2, 4, Burn) Incidental ingestion of pit material (Pits 3, 5, 6) Dermal contact with pit material (Pits 3, 5, 6) Direct radiation Ingestion of vegetables and fruit (Pits 1, 2) Ingestion of meat and dairy products (Pits 1, 2) 	<ul style="list-style-type: none"> Inhalation of VOCs, radon, and particulates Ingestion of vegetables and fruits Ingestion of meat and dairy products 	<ul style="list-style-type: none"> Ingestion of drinking water Dermal contact while bathing Inhalation of volatiles and radon while showering Ingestion of vegetables and fruit Ingestion of meat and dairy products 	<ul style="list-style-type: none"> Ingestion of meat and dairy products 	NA
On-Property Home Builder	<ul style="list-style-type: none"> Incidental ingestion of pit material (Pit 4) Dermal contact with pit material (Pit 4) Direct radiation 	<ul style="list-style-type: none"> Inhalation of VOCs, radon, and particulates 	NA	NA	NA

*NA - Not Applicable

TABLE E.3-3
EXPOSURE POINT CONCENTRATIONS*
ALL SURFACE SOIL (INCLUDING PIT COVERS)

	All Soils
Surface Area (m ²)	1.51 x 10 ⁵
Radionuclides (pCi/g)	
Cs-137	1.0 x 10 ⁰
Np-237	5.0 x 10 ⁻¹
Pu-238	3.8 x 10 ⁻¹
Pu-239/240	1.3 x 10 ⁻¹
Ra-226	9.5 x 10 ⁻¹
Ra-228	1.2 x 10 ⁰
Sr-90	1.7 x 10 ⁰
Tc-99	8.7 x 10 ⁰
Th-228	5.5 x 10 ⁰
Th-230	7.5 x 10 ⁻¹
Th-232	4.3 x 10 ⁰
U-234	6.0 x 10 ⁻¹
U-235	6.8 x 10 ⁰
U-238	2.5 x 10 ²
Chemicals (mg/kg)	
Aroclor-1254	1.40 x 10 ⁰
Antimony	2.72 x 10 ¹
Arsenic	4.90 x 10 ⁰
Barium	5.69 x 10 ¹
Beryllium	8.00 x 10 ⁻¹
Cadmium	5.80 x 10 ⁰
Chromium	1.43 x 10 ¹
Cobalt	1.04 x 10 ¹
Copper	1.70 x 10 ¹
Lead	1.59 x 10 ¹

0515

4782

TABLE E.3-3
(Continued)

	All Soils
Manganese	5.74×10^2
Molybdenum	4.30×10^0
Nickel	2.94×10^1
Silver	8.90×10^0
Uranium	5.22×10^1
Vanadium	1.96×10^1
Zinc	4.67×10^1

*Concentration is the larger of the UCLs calculated for the CIS and RI/FS data bases.

TABLE E.3-4

EXPOSURE POINT CONCENTRATIONS*
EXPOSED PIT MATERIAL AND SURFACE SOIL
FUTURE SOURCE TERM

	Pit 3	Pit 5	Pit 6	Other Surface Soil	Weighted Average
Area(m²)	2.24×10^4	7.50×10^3	1.50×10^3	1.29×10^5	1.60×10^5
Radionuclides (pCi/g)					
Cs-137	ND ^b	7.6×10^1	3.1×10^1	1.0×10^0	4.66×10^0
Np-237	2.1×10^0	4.6×10^1	3.4×10^0	5.0×10^{-1}	2.89×10^0
Pu-238	1.0×10^0	3.6×10^0	1.3×10^0	3.8×10^{-1}	6.27×10^{-1}
Pu-239/240	1.4×10^1	9.7×10^0	1.4×10^1	1.3×10^{-1}	2.65×10^0
Ra-226	3.1×10^2	1.1×10^2	4.4×10^0	9.5×10^{-1}	4.94×10^1
Sr-90	5.2×10^0	2.0×10^1	5.1×10^0	1.7×10^0	3.09×10^0
Tc-99	5.2×10^2	2.1×10^3	1.6×10^2	8.7×10^0	1.80×10^2
Th-230	8.6×10^3	6.8×10^3	4.4×10^1	7.5×10^1	1.58×10^3
Th-232	4.0×10^2	4.5×10^1	1.5×10^0	4.3×10^0	6.16×10^1
U-234	1.1×10^3	9.3×10^2	5.1×10^3	6.0×10^1	2.94×10^2
U-235/236	7.3×10^1	5.4×10^1	1.8×10^3	6.8×10^0	3.51×10^1
U-238	1.3×10^3	9.0×10^2	2.1×10^4	2.4×10^2	6.15×10^2
Inorganics (mg/kg)					
Antimony	5.25×10^1	5.17×10^1	ND	2.72×10^1	3.17×10^1
Arsenic	2.13×10^4	2.15×10^3	5.49×10^1	4.90×10^0	3.09×10^3
Barium	8.08×10^3	3.02×10^4	9.50×10^1	5.69×10^1	2.59×10^3
Beryllium	1.44×10^1	1.48×10^1	5.70×10^0	8.00×10^{-1}	3.41×10^0
Boron	1.55×10^2	ND	ND	ND	2.17×10^1
Cadmium	2.59×10^1	1.16×10^1	5.70×10^0	5.80×10^0	8.90×10^0
Chromium	1.86×10^2	1.16×10^2	3.00×10^1	1.43×10^1	4.33×10^1
Cobalt	3.60×10^1	3.55×10^1	2.60×10^1	1.04×10^1	1.53×10^1
Copper	1.74×10^3	1.18×10^4	2.22×10^2	1.70×10^1	8.13×10^2
Cyanide	1.61×10^0	ND	ND	ND	2.25×10^{-1}
Lead	6.70×10^2	1.68×10^2	7.96×10^1	1.59×10^1	1.16×10^2
Manganese	1.67×10^4	3.05×10^3	2.21×10^2	5.74×10^2	2.95×10^3
Mercury	3.19×10^0	1.59×10^0	ND	ND	5.22×10^{-1}
Molybdenum	2.41×10^2	6.66×10^2	ND	4.30×10^0	6.84×10^1
Nickel	2.66×10^2	1.50×10^2	5.10×10^1	2.94×10^1	6.85×10^1

TABLE E.3-4
(Continued)

	Pit 3	Pit 5	Pit 6	Other Surface Soil	Weighted Average
Area(m²)	2.24×10^4	7.50×10^3	1.50×10^3	1.29×10^5	1.60×10^5
Selenium	4.95×10^1	1.38×10^1	ND	ND	7.58×10^0
Silver	3.74×10^1	1.41×10^1	1.58×10^2	8.90×10^0	1.46×10^1
Thallium	1.20×10^1	3.45×10^1	7.10×10^1	ND	3.96×10^0
Tin	1.91×10^2	4.80×10^1	1.38×10^1	ND	2.90×10^1
Uranium	4.55×10^3	2.76×10^3	1.93×10^4	5.22×10^1	9.89×10^2
Vanadium	5.20×10^3	4.92×10^3	1.00×10^2	1.96×10^1	9.75×10^2
Zinc	3.11×10^2	2.06×10^2	4.80×10^1	4.67×10^1	9.13×10^1
Organics (mg/kg)					
Aroclor-1248	2.73×10^0	5.50×10^{-1}	ND	ND	4.08×10^{-1}
Aroclor-1254	2.08×10^0	7.50×10^{-1}	8.10×10^{-2}	1.40×10^0	1.46×10^0
Benzo(a)anthracene	3.60×10^{-1}	ND	ND	ND	5.04×10^{-2}
Benzo(a)pyrene	2.80×10^{-1}	ND	ND	ND	3.92×10^{-2}
Benzo(b)fluoranthene	5.60×10^{-1}	ND	ND	ND	7.84×10^{-2}
Benzo(g,h,i)perylene	1.60×10^{-1}	ND	ND	ND	2.24×10^{-2}
Chrysene	3.70×10^{-1}	ND	ND	ND	5.18×10^{-2}
Indeno(1,2,3-cd)pyrene	1.30×10^{-1}	ND	ND	ND	1.82×10^{-2}
Pentachlorophenol	1.30×10^0	ND	ND	ND	1.82×10^{-1}
Tetrachloroethene	ND	ND	2.90×10^1	ND	2.72×10^1
Tetrachlorodibenzofuran	2.00×10^{-4}	ND	ND	ND	2.80×10^{-5}
Heptachlorodibenzo-p-dioxin	3.22×10^{-3}	ND	ND	ND	2.94×10^{-4}
Heptachlorodibenzofuran	8.97×10^{-4}	ND	ND	ND	1.26×10^{-4}
Hexachlorodibenzo-p-dioxin	3.08×10^{-4}	ND	ND	ND	4.31×10^{-5}
Hexachlorodibenzofuran	2.67×10^{-4}	ND	ND	ND	3.74×10^{-5}
Octachlorodibenzo-p-dioxin	1.27×10^{-2}	ND	ND	ND	1.78×10^{-3}
Octachlorodibenzofuran	7.45×10^{-4}	ND	ND	ND	1.04×10^{-4}

*Concentration is the larger of the UCLs calculated for the CIS and RI/FS data bases.

^bND - Not detected or is not a CPC for this area. Concentration is assumed to be zero for calculation of weighted average concentration.

TABLE E.3-5
FUTURE EXPOSURE POINT CONCENTRATIONS^a
PIT 4

	Pit 4
Radionuclides (pCi/g)	
Np-237	4.0×10^{-1}
Pu-238	5.0×10^{-1}
Pu-239/240	4.0×10^{-1}
Ra-226	3.7×10^1
Sr-90	9.9×10^1
Tc-99	2.0×10^2
Th-230	1.5×10^3
Th-232	7.1×10^2
U-234	4.1×10^3
U-235/236	9.0×10^2
U-238	4.2×10^4
Inorganics (mg/kg)	
Antimony	2.22×10^2
Arsenic	5.16×10^0
Barium	4.58×10^3
Beryllium	5.06×10^1
Boron	6.58×10^2
Cadmium	2.45×10^1
Chromium	1.05×10^3
Cobalt	1.29×10^2
Copper	3.52×10^2
Lead	5.53×10^1
Manganese	4.75×10^3
Molybdenum	6.98×10^1
Nickel	1.67×10^2
Silver	5.31×10^1
Tin	1.14×10^2

0519

TABLE E.3-5
(Continued)

	Pit 4
Uranium	9.44×10^4
Vanadium	3.94×10^2
Zinc	1.43×10^2
Organics (mg/kg)	
Aroclor-1242	1.03×10^0
Aroclor-1248	5.92×10^0
Aroclor-1254	6.80×10^0
Acenaphthene	1.90×10^0
Anthracene	2.70×10^0
Benzo(a)anthracene	4.70×10^0
Benzo(a)pyrene	4.50×10^0
Benzo(b)fluoranthene	5.20×10^0
Benzo(k)fluoranthene	3.70×10^0
Benzo(g,h,i)perylene	9.90×10^{-1}
Chrysene	3.86×10^0
Dibenzofuran	1.40×10^0
Fluoranthene	1.10×10^1
Flourene	2.20×10^0
Indeno(1,2,3-cd) pyrene	9.90×10^{-1}
Naphthalene	1.10×10^0
Phenanthrene	1.20×10^1
Pyrene	9.00×10^0
4-Nitrophenol	2.30×10^0
Tetrachloroethene	3.00×10^1
Tetrachlorodibenzo-p-dioxin	4.70×10^4
Tetrachlorodibenzofuran	3.11×10^{-2}
Heptachlorodibenzo-p-dioxin	3.16×10^{-3}
Heptachlorodibenzofuran	5.58×10^{-3}
Hexachlorodibenzo-p-dioxin	2.29×10^{-3}
Hexachlorodibenzofuran	9.5×10^{-3}

0520

TABLE E.3-5
(Continued)

4787

	Pit 4
Octachlorodibenzo-p-dioxin	6.52×10^{-3}
Octachlorodibenzofuran	3.66×10^{-3}
1,2,3,7,8-Pentachlorodibenzofuran	1.39×10^{-3}
2,3,4,7,8-Pentachlorodibenzofuran	1.74×10^{-3}
Tributyl phosphate	7.20×10^1

^a Concentration is the larger of the UCLs calculated for the CIS and RI/FS data bases.

4787

TABLE E.3-6
MICROSHIELD INPUT PARAMETERS FOR
CURRENT LAND USE OF OU-1

	Pit 1	Pit 2	Pit 3	Pit 4	Pit 5	Pit 6	Burn Pit
Geometry	Cylinder	Cylinder	Cylinder	Cylinder	---	---	Cylindrical
Source radius (m)	49.4	36.4	84.4	49.8	---	---	25.5
Source density (g/cm ³)	1.94	0.682	0.735	1.58	---	---	1.13
Shield No. 2							
density (g/cc)	1.5	1.5	1.5	1.5	---	---	1.5
thickness (m)	0.3	0.38	0.33	1.33	---	---	0.19
Air gap thickness (m)	0	0	0	0	---	---	0
Distance from source (m)	0	0	0	0	---	---	0
Source term*	Pit 1 material	Pit 2 material	Pit 3 material	Pit 4 material	---	---	Burn pit material

* The source term includes the daughters of all radionuclides in the current inventory. The daughter concentrations are obtained by calculating the concentration of the current inventory 120 years ago, then allowing the concentrations of the 120 years ago to decay for 120 years. This process brings the concentrations of the parent radionuclides back to their current values, and adds the daughter concentrations to the inventory as well.

TABLE E.3-7
MICROSHIELD INPUT PARAMETERS FOR
FUTURE LAND USE OF OU-1

	Pit 1	Pit 2	Pit 3	Pit 4	Pit 5	Pit 6	Burn Pit
Geometry	---	---	Cylinder	---	Rectangular	Rectangular	---
Source dimensions (m)	---	---	84.4	---	86.6 x 86.6 x 8.5	38.9 x 38.9 x 24	---
Source density (g/cm ³)	---	---	0.735	---	0.411	1.22	---
Shield No. 2							
Density (g/cc)	---	---	0	---	0	0	---
Thickness (m)	---	---	0	---	0	0	---
Air gap thickness (m)	---	---	0.001	---	0.01	0.01	---
Distance from source (m)	---	---	0.001	---	0.01	0.01	---
Source term *	---	---	Pit 3 material	---	Pit 5 material	Pit 6 material	---

* The source term is the current inventory allowed to decay for 100 years.

4787

TABLE E.3-8

DOSE RATES AT 1 METER ABOVE
OPERABLE UNIT 1 SOURCE PITS^a
(mrem/hr)

	Current Source Term ^b Configuration	Future Source Term ^b Configuration
Pit 1	2.4×10^{-2}	2.4×10^{-2}
Pit 2	5.7×10^{-2}	5.7×10^{-2}
Pit 3	4.4×10^{-2}	1.3 ^c
Pit 4	7.8×10^{-6}	7.8×10^{-6}
Pit 5	NA ^d	54 ^e
Pit 6	NA ^d	156 ^e
Burn Pit	0.14	0.14
Clearwell	NA ^d	NA ^d

^aThe source pits were modeled as circular slabs having a surface areas equal to each pit.

^bIncludes all radionuclides detected in the source plus their short-lived daughters.

^cPit 3 is assumed to have no soil cover in the future source term configuration.

^dThis pit is assumed to be covered with water.

^ePits 5 and 6 were modeled assuming half their contents are exposed to air in the future.

4787

TABLE E.3-9
EXPOSURE POINT CONCENTRATIONS
ON-PROPERTY SURFACE WATER
CURRENT SOURCE TERM

	Surface Water in Pit 5	Surface Water in Pit 6	Surface Water in Clearwell	Area Weighted Average
Surface Area (m²)	1.50×10^4	3.01×10^3	2.74×10^3	2.075×10^4
Radionuclides (pCi/L)				
Cs-137	9.00×10^1	ND*	ND	6.5×10^1
Ra-226	ND	ND	1.10×10^0	1.45×10^1
Ra-228	ND	2.57×10^1	ND	3.73×10^1
Sr-90	4.10×10^1	ND	ND	2.96×10^1
Tc-99	3.20×10^2	2.75×10^3	4.03×10^3	1.16×10^3
Th-230	1.00×10^1	3.00×10^1	4.00×10^1	1.9×10^1
U-234	4.20×10^2	7.70×10^1	1.90×10^3	5.66×10^2
U-235	1.90×10^1	9.30×10^0	1.20×10^2	3.10×10^1
U-238	4.00×10^2	4.60×10^2	6.20×10^3	1.17×10^3
Chemicals (mg/L)				
Benzene	1.10×10^{-2}	ND	ND	7.95×10^{-3}
Antimony	4.50×10^{-3}	1.70×10^{-3}	ND	3.0×10^{-3}
Arsenic	2.10×10^{-3}	ND	4.20×10^{-3}	2.07×10^{-3}
Barium	1.08×10^1	ND	ND	7.81×10^{-2}
Copper	2.10×10^{-2}	ND	1.90×10^{-2}	1.77×10^{-2}
Cyanide	8.70×10^{-2}	1.00×10^{-2}	8.70×10^{-2}	7.58×10^{-2}
Lead	2.90×10^{-3}	2.90×10^{-3}	ND	2.52×10^{-3}
Nickel	2.10×10^{-2}	ND	ND	1.52×10^{-2}
Selenium	2.10×10^{-3}	ND	3.00×10^{-3}	1.91×10^{-3}
Silver	ND	ND	1.40×10^{-2}	1.85×10^{-3}
Vanadium	4.70×10^{-2}	ND	5.13×10^{-1}	1.02×10^{-1}
Zinc	1.14×10^1	1.14×10^1	4.70×10^{-2}	1.05×10^{-1}

* ND - Not detected or is not a CPC for this area. Concentration assumed to be zero for calculation of weighted average concentration.

TABLE E.3-10
EXPOSURE POINT CONCENTRATIONS
ON-PROPERTY SURFACE WATER
FUTURE SOURCE TERM

	Surface Water in Pit 5	Surface Water in Pit 6	Surface Water in Clearwell	Area Weighted Average
Surface area (m ²)	7.50 x 10 ⁴	1.51 x 10 ³	2.74 x 10 ³	1.2 x 10 ⁴
Radionuclides (pCi/L)				
Cs-137	9.00 x 10 ¹	ND ^a	ND	5.6 x 10 ¹
Ra-226	ND	ND	1.10 x 10 ⁰	2.5 x 10 ⁻¹
Sr-90	4.10 x 10 ¹	ND	ND	2.6 x 10 ¹
Tc-99	3.20 x 10 ²	2.75 x 10 ³	4.03 x 10 ³	1.5 x 10 ³
Th-230	1.00 x 10 ⁻¹	3.00 x 10 ⁻¹	4.00 x 10 ⁻¹	1.9 x 10 ⁻¹
U-234	4.20 x 10 ²	7.70 x 10 ¹	1.90 x 10 ³	7.1 x 10 ²
U-235	1.90 x 10 ¹	9.30 x 10 ⁰	1.20 x 10 ²	4.0 x 10 ¹
U-238	4.00 x 10 ²	4.60 x 10 ²	6.20 x 10 ³	1.7 x 10 ³
Chemicals (mg/L)				
Benzene	1.10 x 10 ⁻²	ND	ND	6.9 x 10 ⁻³
Antimony	4.50 x 10 ⁻³	1.70 x 10 ⁻³	ND	3.0 x 10 ⁻³
Arsenic	2.10 x 10 ⁻³	ND	4.20 x 10 ⁻³	2.3 x 10 ⁻³
Barium	1.08 x 10 ⁻¹	ND	ND	6.8 x 10 ⁻²
Copper	2.10 x 10 ⁻²	ND	1.90 x 10 ⁻²	1.8 x 10 ⁻²
Cyanide	8.70 x 10 ⁻²	1.00 x 10 ⁻²	8.70 x 10 ⁻²	7.6 x 10 ⁻²
Lead	2.90 x 10 ⁻³	2.90 x 10 ⁻³	ND	2.2 x 10 ⁻³
Nickel	2.10 x 10 ⁻²	ND	ND	1.3 x 10 ⁻²
Selenium	2.10 x 10 ⁻³	ND	3.00 x 10 ⁻³	2.0 x 10 ⁻³
Silver	ND	ND	1.40 x 10 ⁻²	3.2 x 10 ⁻³
Vanadium	4.70 x 10 ⁻²	ND	5.13 x 10 ⁻¹	1.5 x 10 ⁻¹
Zinc	1.14 x 10 ⁻¹	1.14 x 10 ⁻¹	4.70 x 10 ⁻²	9.6 x 10 ⁻¹

^a ND - Not detected or is not a CPC for this area. Concentration is assumed to be zero for calculation of weighted average concentration.

TABLE E.3-11
ESTIMATED EXPOSURE POINT CONCENTRATIONS
GREAT MIAMI RIVER

4787

Chemical	Concentration
Radionuclide (pCi/L)	
Cs-137	2.80×10^{-6}
Np-237	4.61×10^{-5}
Pu-238	1.20×10^{-6}
Pu-239/240	2.99×10^{-7}
Sr-90	8.72×10^{-4}
Tc-99	2.02×10^{-1}
Th-230	6.58×10^{-5}
Th-232	3.79×10^{-6}
U-234	2.53×10^{-2}
U-235	2.86×10^{-3}
U-238	1.03×10^{-1}
Inorganics and Organics (mg/L)	
Aroclor-1254	1.1×10^{-10}
Aroclor-1260	1.6×10^{-10}
Antimony	6.9×10^{-7}
Arsenic	1.0×10^{-7}
Barium	2.5×10^{-7}
Beryllium	3.1×10^{-9}
Cadmium	5.9×10^{-8}
Chromium	4.9×10^{-8}
Cobalt	9.6×10^{-8}
Copper	6.9×10^{-7}
Lead	2.7×10^{-8}
Manganese	1.6×10^{-5}
Molybdenum	2.4×10^{-7}
Nickel	2.3×10^{-7}
Silver	2.5×10^{-7}
Thallium	2.4×10^{-9}
Uranium*	3.1×10^{-4}
Vanadium	1.0×10^{-7}
Zinc	9.9×10^{-8}

0527

*Calculated from radioisotopic results

4787

TABLE E.3-12
ESTIMATED EXPOSURE POINT CONCENTRATIONS
PADDYS RUN SEDIMENT

Chemical	Concentration
Radiological (pCi/g)	
Cs-137	1.0×10^0
Np-237	5.0×10^{-1}
Pu-238	4.0×10^{-1}
Pu-239/240	1.0×10^{-1}
Sr-90	1.7×10^0
Tc-99	4.7×10^0
Th-230	7.5×10^1
Th-232	4.3×10^0
U-234	6.0×10^1
U-235	6.7×10^0
U-238	2.4×10^2
Organics (mg/kg)	
Aroclor-1254	1.4×10^0
Aroclor-1260	2.0×10^{-1}
Inorganics (mg/kg)	
Antimony	2.72×10^1
Arsenic	4.90×10^0
Barium	5.69×10^1
Beryllium	8.00×10^{-1}
Cadmium	5.80×10^0
Chromium	1.43×10^1
Cobalt	1.04×10^1
Copper	1.70×10^1
Lead	1.59×10^1
Manganese	5.74×10^2
Molybdenum	4.30×10^0
Nickel	2.94×10^1

TABLE E.3-12
(Continued)

4787

Chemical	Concentration
Silver	8.89×10^0
Thallium	7.00×10^{-1}
Uranium*	7.30×10^2
Vanadium	1.96×10^1
Zinc	4.67×10^1

*Concentration calculated from radioisotopic results.

4787

TABLE E.3-13

MAXIMUM ESTIMATED EXPOSURE POINT CONCENTRATIONS
ON- AND OFF-PROPERTY GROUNDWATER
FUTURE SOURCE TERM

Constituents	Great Miami Aquifer On-Property (630 years)	Great Miami Aquifer Off-Property (680 years)	Perched Water On-Property
Radionuclides (pCi/L)			
Cs-137	NA ^a	NA	9.01×10^1
Np-237	1.16×10^{-4}	1.24×10^{-11}	7.47×10^0
Pu-238	1.33×10^{-1}	NA	4.89×10^{-1}
Pu-239/240	NA	NA	4.96×10^{-2}
Ra-226	1.78×10^0	NA	7.25×10^1
Sr-90	4.69×10^{-3}	5.9×10^{-6}	4.03×10^1
Tc-99	1.65×10^1	3.13×10^0	2.74×10^3
Th-230	1.04×10^0	NA	3.03×10^{-1}
Th-232	NA	NA	5.06×10^{-2}
U-234	8.83×10^2	6.24×10^1	1.49×10^5
U-235	2.05×10^2	1.44×10^1	2.76×10^4
U-238	4.18×10^3	2.95×10^2	4.29×10^5
Inorganics (mg/L)			
Antimony	1.75×10^{-1}	NA	9.56×10^{-1}
Arsenic	5.82×10^{-1}	NA	6.32×10^{-1}
Barium	6.51×10^{-1}	4.77×10^{-7}	1.96×10^0
Beryllium	NA	NA	2.04×10^{-2}
Boron	3.08×10^{-2}	6.77×10^{-3}	2.93×10^0
Cadmium	NA	NA	1.18×10^{-1}
Chromium	NA	NA	1.29×10^{-1}
Cobalt	NA	NA	3.38×10^{-1}
Copper	NA	NA	9.48×10^{-1}
Cyanide	4.22×10^{-6}	1.24×10^{-8}	3.60×10^0
Lead	5.80×10^{-2}	NA	6.91×10^{-1}

0530

TABLE E.3-13
(Continued)

Constituents	Great Miami Aquifer On-Property (630 years)	Great Miami Aquifer Off-Property (680 years)	Perched Water On-Property
Manganese	2.07×10^0	NA	2.41×10^0
Mercury	NA	NA	2.18×10^{-2}
Molybdenum	NA	NA	1.15×10^2
Nickel	NA	NA	2.13×10^0
Selenium	NA	NA	3.80×10^{-3}
Silver	NA	NA	6.67×10^{-2}
Thallium	NA	NA	7.54×10^{-1}
Tin	NA	NA	8.29×10^0
Uranium	1.26×10^1	8.87×10^{-1}	5.00×10^2
Vanadium	NA	NA	1.44×10^0
Zinc	NA	NA	1.79×10^0
Organics (mg/L)			
Aroclor-1248	NA	NA	5.0×10^{-2}
Aroclor-1254	NA	NA	1.0×10^{-1}
Acenaphthene	NA	NA	4.0×10^{-2}
Anthracene	NA	NA	4.0×10^{-2}
Benzo(a)anthracene	NA	NA	4.0×10^{-2}
Benzo(a)pyrene	NA	NA	4.0×10^{-2}
Benzo(b)fluoranthene	NA	NA	4.0×10^{-2}
Benzo(k)fluoranthene	NA	NA	4.0×10^{-2}
Chrysene	NA	NA	4.0×10^{-2}
Dibenzo(a,h)anthracene	NA	NA	1.0×10^{-2}
Fluoranthene	NA	NA	4.0×10^{-2}
Fluorene	NA	NA	4.0×10^{-2}
Indeno(1,2,3-cd)pyrene	NA	NA	4.0×10^{-2}
Naphthalene	NA	NA	1.6×10^{-2}
Phenanthrene	NA	NA	4.0×10^{-2}
Pyrene	NA	NA	4.0×10^{-2}
4-Nitrophenol	NA	NA	1.0×10^{-2}

TABLE E.3-13
(Continued)

Constituents	Great Miami Aquifer On-Property (630 years)	Great Miami Aquifer Off-Property (680 years)	Perched Water On-Property
Pentachlorohenol	NA	NA	2.0×10^{-1}
Tetrachloroethene	NA	NA	1.4×10^{-1}
Vinyl chloride	NA	NA	1.0×10^0
TCDF	NA	NA	5.3×10^{-6}
HpCDD	NA	NA	9.4×10^{-7}
HpCDF	NA	NA	2.0×10^{-6}
HxCDD	NA	NA	7.5×10^{-7}
HxCDF	NA	NA	1.2×10^{-6}
OCDD	NA	NA	1.8×10^{-6}
OCDF	NA	NA	1.1×10^{-6}
1,2,3,7,8-PeCDF	NA	NA	1.0×10^{-6}
2,3,4,7,8-PeCDF	NA	NA	1.1×10^{-6}

*NA - Not applicable. Contaminant did not pass screening or was not detected.

0532

4787

TABLE E.3-14
ESTIMATED EXPOSURE POINT CONCENTRATIONS
AIR - PM10
CURRENT SOURCE TERM

Airborne Contaminant	Maximum On-Property Location	Maximum Off-Property Location
Radionuclides (pCi/m³)		
Cs-137	2.9×10^{-4}	2.5×10^{-5}
Np-237	1.4×10^{-4}	1.2×10^{-5}
Pu-238	1.1×10^{-4}	9.5×10^{-6}
Pu-239/240	3.7×10^{-5}	3.2×10^{-6}
Ra-226	2.7×10^{-4}	2.4×10^{-5}
Ra-228	3.4×10^{-4}	3.0×10^{-5}
Rn-222	2.8×10^1	2.3×10^0
Sr-90	4.9×10^{-4}	4.2×10^{-5}
Tc-99	2.5×10^{-3}	2.2×10^{-4}
Th-228	1.6×10^{-3}	1.4×10^{-4}
Th-230	2.1×10^{-2}	1.9×10^{-3}
Th-232	1.2×10^{-3}	1.1×10^{-4}
U-234	1.7×10^{-2}	1.5×10^{-3}
U-235/236	1.9×10^{-3}	1.7×10^{-4}
U-238	7.0×10^{-2}	6.2×10^{-3}
Chemicals (mg/m³)		
Aroclor-1254	4.0×10^{-7}	3.5×10^{-8}
Antimony	7.8×10^{-6}	6.8×10^{-7}
Arsenic	1.4×10^{-6}	1.2×10^{-7}
Barium	1.6×10^{-5}	1.4×10^{-6}
Beryllium	2.3×10^{-7}	2.0×10^{-8}
Cadmium	1.7×10^{-6}	1.5×10^{-7}
Chromium	4.1×10^{-6}	3.6×10^{-7}
Cobalt	3.0×10^{-6}	2.6×10^{-7}
Copper	4.9×10^{-6}	4.2×10^{-7}
Lead	4.5×10^{-6}	4.0×10^{-7}
Manganese	1.6×10^{-4}	1.4×10^{-5}
Molybdenum	1.2×10^{-6}	1.1×10^{-7}
Nickel	8.5×10^{-6}	7.4×10^{-7}
Silver	2.5×10^{-6}	2.2×10^{-7}
Uranium	1.5×10^{-6}	1.3×10^{-6}

4782

TABLE E.3-14
(Continued)

Airborne Contaminant	Maximum On-Property Location	Maximum Off-Property Location
Vanadium	5.6×10^{-6}	4.9×10^{-7}
Zinc	1.3×10^{-6}	1.2×10^{-7}

1534

TABLE E.3-15
ESTIMATED EXPOSURE POINT CONCENTRATIONS
AIR - PM10
FUTURE SOURCE TERM

4787

Airborne Contaminant	Maximum On-Property Location	Maximum Off-Property Location
Radionuclides (pCi/m³)		
Cs-137	1.6 x 10 ⁻³	1.9 x 10 ⁻⁴
Np-237	1.3 x 10 ⁻³	1.4 x 10 ⁻⁴
Pu-238	2.9 x 10 ⁻⁴	2.7 x 10 ⁻⁵
Pu-239/240	3.0 x 10 ⁻³	2.5 x 10 ⁻⁴
Ra-226	6.3 x 10 ⁻²	5.2 x 10 ⁻³
Rn-222	4.8 x 10 ²	4.0 x 10 ¹
Sr-90	1.5 x 10 ⁻³	1.4 x 10 ⁻⁴
Tc-99	1.4 x 10 ⁻¹	1.3 x 10 ⁻²
Th-230	1.8 x 10 ⁰	1.5 x 10 ⁻¹
Th-232	8.0 x 10 ⁻²	6.5 x 10 ⁻³
U-234	2.6 x 10 ⁻¹	2.3 x 10 ⁻²
U-235/236	2.3 x 10 ⁻¹	2.2 x 10 ⁻³
U-238	3.6 x 10 ⁻¹	3.4 x 10 ⁻²
Inorganics (mg/m³)		
Antimony	1.3 x 10 ⁻⁵	1.1 x 10 ⁻⁶
Arsenic	4.2 x 10 ⁻³	3.4 x 10 ⁻⁴
Barium	2.2 x 10 ⁻³	2.0 x 10 ⁻⁴
Beryllium	3.2 x 10 ⁻⁶	2.7 x 10 ⁻⁷
Boron	3.1 x 10 ⁻⁵	2.5 x 10 ⁻⁸
Cadmium	5.7 x 10 ⁻⁶	4.8 x 10 ⁻⁷
Chromium	4.0 x 10 ⁻⁵	3.3 x 10 ⁻⁶
Cobalt	8.4 x 10 ⁻⁶	7.3 x 10 ⁻⁷
Copper	5.7 x 10 ⁻⁴	5.5 x 10 ⁻⁵
Cyanide	3.2 x 10 ⁻⁷	2.6 x 10 ⁻⁸
Lead	1.4 x 10 ⁻⁴	1.1 x 10 ⁻⁵
Manganese	3.4 x 10 ⁻³	2.8 x 10 ⁻⁴

4787

TABLE E.3-15
(Continued)

Airborne Contaminant	Maximum On-Property Location	Maximum Off-Property Location
Mercury	6.6×10^{-7}	5.5×10^{-8}
Molybdenum	6.0×10^{-5}	5.4×10^{-6}
Nickel	5.7×10^{-5}	4.8×10^{-2}
Selenium	1.0×10^{-5}	8.2×10^{-7}
Silver	8.7×10^{-6}	7.6×10^{-7}
Thallium	3.3×10^{-6}	3.0×10^{-7}
Tin	3.9×10^{-5}	3.2×10^{-6}
Uranium	1.0×10^0	8.9×10^{-2}
Vanadium	1.1×10^{-3}	9.4×10^{-5}
Zinc	6.8×10^{-5}	5.7×10^{-6}
Organics (mg/m³)		
Aroclor-1248	5.5×10^{-7}	4.4×10^{-8}
Aroclor-1254	5.0×10^{-7}	4.0×10^{-8}
Benzo(a)anthracene	7.1×10^{-8}	5.7×10^{-9}
Benzo(a)pyrene	7.5×10^{-7}	6.1×10^{-9}
Benzo(b)fluoranthene	1.1×10^{-8}	8.9×10^{-9}
Benzo(g,h,i)perylene	3.2×10^{-8}	2.5×10^{-9}
Chrysene	7.3×10^{-8}	5.9×10^{-9}
Indeno(123-cd)pyrene	2.6×10^{-8}	2.1×10^{-9}
Pentachlorophenol	2.6×10^{-7}	2.1×10^{-8}
Tetrachloroethene	1.2×10^{-7}	1.5×10^{-8}
2,3,7,8-Tetrachlorodibenzofuran	3.9×10^{-11}	3.2×10^{-12}
Heptachlorodibenzo-p-dioxin	6.3×10^{-10}	3.3×10^{-11}
Heptachlorodibenzofuran	1.7×10^{-10}	1.1×10^{-11}
Hexachlorodibenzo-p-dioxin	5.3×10^{-11}	4.1×10^{-12}
Hexachlorodibenzofuran	5.5×10^{-11}	4.3×10^{-12}
Octachlorodibenzo-p-dioxin	2.5×10^{-9}	2.0×10^{-10}
Octachlorodibenzofuran	1.5×10^{-10}	1.2×10^{-11}

0536

TABLE E.3-16
EXPOSURE INPUT PARAMETERS
CURRENT SOURCE TERM RECEPTORS

Pathway Parameters (units)	Trespassing Child Age 7-18	Off-Property RME Resident Adult Farmer Age 1-70	User of Meat & Milk Grown Within Operable Unit 1 Age 1-70	On-Property Visitor Age 19-43
Inhalation of dust, volatiles, and radon				
IR (m ³ /hr)	0.83 ^a	0.83 ^a	NA ^b	2.0 ^d
IR indoor (m ³ /d)	NA	15 ⁱ	NA	NA
ET indoors (hr/day)	NA	18.3 ^e	NA	NA
ET outdoors (hr/day)	4 ^d	5.7 ^e	NA	2 ^d
EF (day/yr)	52 ^d	350 ^e	NA	250 ^e
ED (yr)	12 ^d	70 ^e	NA	25 ^d
BW (kg)	43 ^a	70 ^e	NA	70 ^e
AT-Noncancer (day)	4380 ^a	25550 ^e	NA	9125 ^a
AT-Cancer (day)	25550 ^a	25550 ^e	NA	25550 ^a
Incidental ingestion of soil/sediment				
IR (g/day)	0.1 ^a	NA	NA	NA
FI	0.25 ^b	NA	NA	NA
EF (day/yr)	52 ^d	NA	NA	NA
ED (yr)	12 ^d	NA	NA	NA
BW (kg)	43 ^a	NA	NA	NA
AT-Noncancer (day)	4380 ^a	NA	NA	NA
AT-Cancer (day)	25550 ^a	NA	NA	NA
Dermal contact with soil/sediment				
SA (m ²)	0.38 ⁱ	NA	NA	NA
AF (mg/cm ²)	1.00 ⁱ	NA	NA	NA
ABS (unitless)	csv	NA	NA	NA
EF (day/yr)	52 ^d	NA	NA	NA
ED (yr)	12 ^d	NA	NA	NA

TABLE E.3-16
(Continued)

Pathway Parameters (units)	Trespassing Child Age 7-18	Off-Property RME Resident Adult Farmer Age 1-70	User of Meat & Milk Grown Within Operable Unit 1 Age 1-70	On-Property Visitor Age 19-43
BW (kg)	43*	NA	NA	NA
AT-Noncancer (day)	4380*	NA	NA	NA
AT-Cancer (day)	25550*	NA	NA	NA
External radiation exposure				
DR (mrem/hr)	csv	NA	NA	csv
ET indoors (hr/day)	NA	NA	NA	NA
ET outdoors (hr/day)	4*	NA	NA	2*
EF (day/yr)	52*	NA	NA	250*
ED (yr)	12*	NA	NA	25*
SH indoors (unitless)	NA	NA	NA	NA
SH outdoors (unitless)	0*	NA	NA	0*
Ingestion of vegetables and fruit				
IR(fruit) x FI (g/day)	NA	42*	NA	NA
IR(vegetables) x FI (g/day)	NA	80*	NA	NA
EF (day/yr)	NA	350*	NA	NA
ED (yr)	NA	70*	NA	NA
BW (kg)	NA	70*	NA	NA
AT-Noncancer (day)	NA	25550*	NA	NA
AT-Cancer (day)	NA	25550*	NA	NA
Ingestion of meat, milk, and fish				
IR(meat) x FI (g/day)	NA	75*	75*	NA
IR(milk) x FI (L/day)	NA	0.3*	0.3*	NA
IR(fish) x FI (g/day)	NA	NA	NA	NA
EF (day/yr)	NA	350*	350*	NA

1287

TABLE E.3-16
(Continued)

Pathway Parameters (units)	Trespassing Child Age 7-18	Off-Property RME Resident Adult Farmer Age 1-70	User of Meat & Milk Grown Within Operable Unit 1 Age 1-70	On-Property Visitor Age 19-43
ED (yr)	NA	70*	70*	NA
BW (kg)	NA	70*	70*	NA
AT-Noncancer (day)	NA	25550*	25550*	NA
AT-Cancer (day)	NA	25550*	25550*	NA

*DOE 1992a, Risk Assessment Work Plan Addendum.

*NA - Not applicable.

*Assumes the RME works outdoors 2000 hours/year.

*EPA Region V.

*EPA 1991a.

*EPA 1992c, EPA 600/8-91/011b.

*csv - Chemical Specific Value.

*Adjusted based on 25% of waking hours spent on property, as per EPA Region V.

*EPA 1992e, EPA/600/8-91/011b.

*EPA 1991f.

4282

TABLE E.3-17

**EXPOSURE INPUT PARAMETERS
FUTURE SOURCE TERM RECEPTORS**

Pathway Parameters (units)	Trespassing Child Age 7-18	Off-Property RME Resident Adult Farmer Age 1-70	User of Meat & Milk Grown Within Operable Unit 1 Age 1-70	User of Great Miami River Water Age 1-70	On-Property CT Resident Adult Farmer Age 1-70	On-Property RME Resident Adult Farmer Age 1-70	On-Property RME Resident Child Age 1-6	On-Property Home Building Age 19+
Inhalation of dusts, volatiles, and radon								
IR (m ³ /hr)	0.83 ^a	0.83 ^a	NA ^b	NA	0.83 ^a	0.83 ^a	0.5 ^a	0.83 ^a
IR indoor (m ³ /d)	NA	15 ^a	NA	NA	15 ^a	15 ^a	0.6 ^a	NA
ET indoors (hr/day)	NA	18.3 ^a	NA	NA	19.8 ^d	18.3 ^a	22 ^a	5 ^f
ET outdoors (hr/day)	4 ^d	5.7 ^a	NA	NA	4.2 ^d	5.7 ^a	2 ^a	5 ^f
EF (day/yr)	52 ^d	350 ^a	NA	NA	275 ^d	350 ^a	350 ^a	50 ^f
ED (yr)	12 ^d	70 ^a	NA	NA	9 ^d	70 ^a	6 ^a	1 ^f
BW (kg)	43 ^a	70 ^a	NA	NA	70 ^a	70 ^a	15 ^a	70 ^a
AT-Noncancer (day)	4380 ^a	25550 ^a	NA	NA	3285 ^a	25550 ^a	2190 ^a	365 ^a
AT-Cancer (day)	25550 ^a	25550 ^a	NA	NA	25550 ^a	25550 ^a	25550 ^a	25550 ^a
Drinking water								
IR x FI (L/day)	NA	2 ^a	NA	2 ^a	1.4 ^d	2 ^a	1.4 ^a	NA
EF (day/yr)	NA	350 ^a	NA	350 ^a	275 ^d	350 ^a	350 ^a	NA
ED (yr)	NA	70 ^a	NA	70 ^a	9 ^d	70 ^a	6 ^a	NA
BW (kg)	NA	70 ^a	NA	70 ^a	70 ^a	70 ^a	15 ^a	NA
AT-Noncancer (day)	NA	25550 ^a	NA	25550 ^a	3285 ^a	25550 ^a	2190 ^a	NA
AT-Cancer (day)	NA	25550 ^a	NA	25550 ^a	25550 ^a	25550 ^a	25550 ^a	NA
Inhalation of volatiles released from water by showering and other household uses								
IR (m ³ /d)	NA	15 ^a	NA	15 ^a	15 ^a	15 ^a	15 ^a	NA
EF (day/yr)	NA	350 ^a	NA	350 ^a	275 ^d	350 ^a	350 ^a	NA
ED (yr)	NA	70 ^a	NA	70 ^a	9 ^d	70 ^a	6 ^a	NA
BW (kg)	NA	70 ^a	NA	70 ^a	70 ^a	70 ^a	15 ^a	NA
AT-Noncancer (day)	NA	25550 ^a	NA	25550 ^a	3285 ^a	25550 ^a	2190 ^a	NA
AT-Cancer (day)	NA	25550 ^a	NA	25550 ^a	25550 ^a	25550 ^a	25550 ^a	NA
Dermal contact while bathing								
SA (m ²)	NA	2.0 ^a	NA	2.0 ^a	2.0 ^a	2.0 ^a	0.72 ^b	NA
PC (cm/hr)	NA	csv ⁱ	NA	csv	csv	csv	csv	NA
ET (hr/day)	NA	0.25 ^a	NA	0.25 ^a	0.17 ^a	0.25 ^a	0.33 ^a	NA

TABLE E.3-17
(Continued)

Pathway Parameters (units)	Trespassing Child Age 7-18	Off-Property RME Resident Adult Farmer Age 1-70	User of Meat & Milk Grown Within Operable Unit 1 Age 1-70	User of Great Miami River Water Age 1-70	On-Property CT Resident Adult Farmer Age 1-70	On-Property RME Resident Adult Farmer Age 1-70	On-Property RME Resident Child Age 1-6	On-Property Home Building Age 19+
EF (day/yr)	NA	350 ^a	NA	350 ^a	275 ^d	350 ^a	350 ^a	NA
ED (yr)	NA	70 ^a	NA	70 ^a	9 ^d	70 ^a	6 ^a	NA
BW (kg)	NA	70 ^a	NA	70 ^a	70 ^a	70 ^a	15 ^a	NA
AT-Noncancer (day)	NA	25550 ^a	NA	25550 ^a	3285 ^a	25550 ^a	2190 ^a	NA
AT-Cancer (day)	NA	25550 ^a	NA	25550 ^a	25550 ^a	25550 ^a	25550 ^a	NA
Incidental ingestion while swimming								
IR x FI (L/hr)	NA	NA	NA	0.05 ^a	NA	NA	NA	NA
ET (hr/day)	NA	NA	NA	2.6 ^a	NA	NA	NA	NA
EF (day/yr)	NA	NA	NA	7 ^a	NA	NA	NA	NA
ED (yr)	NA	NA	NA	30 ^a	NA	NA	NA	NA
BW (kg)	NA	NA	NA	70 ^a	NA	NA	NA	NA
AT-Noncancer (day)	NA	NA	NA	10950 ^a	NA	NA	NA	NA
AT-Cancer (day)	NA	NA	NA	25550 ^a	NA	NA	NA	NA
Dermal contact while swimming								
SA (m ²)	NA	NA	NA	2.0 ^a	NA	NA	NA	NA
PC (cm/hr)	NA	NA	NA	csv	NA	NA	NA	NA
ET (hr/day)	NA	NA	NA	2.6 ^a	NA	NA	NA	NA
EF (day/yr)	NA	NA	NA	7 ^a	NA	NA	NA	NA
ED (yr)	NA	NA	NA	30 ^a	NA	NA	NA	NA
BW (kg)	NA	NA	NA	70 ^a	NA	NA	NA	NA
AT-Noncancer (day)	NA	NA	NA	10950 ^a	NA	NA	NA	NA
AT-Cancer (day)	NA	NA	NA	25550 ^a	NA	NA	NA	NA
Incidental ingestion of soil/sediment								
IR (g/day)	0.1 ^a	NA	NA	NA	0.122 ^d	0.18 ^a	0.2 ^a	0.48 ^d
FI	0.25 ^p	NA	NA	NA	1 ^a	1 ^a	1 ^a	1 ^a
EF (day/yr)	52 ^d	NA	NA	NA	275 ^d	350 ^a	350 ^a	50 ^d
ED (yr)	12 ^d	NA	NA	NA	9 ^d	70 ^a	6 ^a	1 ^a
BW (kg)	43 ^a	NA	NA	NA	70 ^a	70 ^a	15 ^a	70 ^a
AT-Noncancer (day)	4380 ^a	NA	NA	NA	3285 ^a	25550 ^a	2190 ^a	365 ^a

TABLE E.3-17
(Continued)

Pathway Parameters (units)	Trespassing Child Age 7-18	Off-Property RME Resident Adult Farmer Age 1-70	User of Meat & Milk Grown Within Operable Unit 1 Age 1-70	User of Great Miami River Water Age 1-70	On-Property CT Resident Adult Farmer Age 1-70	On-Property RME Resident Adult Farmer Age 1-70	On-Property RME Resident Child Age 1-6	On-Property Home Building Age 19+
AT-Cancer (day)	25550 ^a	NA	NA	NA	25550 ^a	25550 ^a	25550 ^a	25550 ^a
Dermal contact with soil/sediment								
SA (m ²)	0.38 ^j	NA	NA	NA	0.5 ^j	0.5 ^j	0.18 ^j	0.5 ^j
AF (mg/cm ²)	1.00 ^k	NA	NA	NA	0.2 ^k	1.0 ^k	1.0 ^k	1.0 ^k
ABS (unitless)	csv	NA	NA	NA	csv	csv	csv	csv
EF (day/yr)	52 ^d	NA	NA	NA	40 ^j	350 ^a	350 ^a	50 ^f
ED (yr)	12 ^d	NA	NA	NA	9 ^d	70 ^a	6 ^a	1 ^f
BW (kg)	43 ^a	NA	NA	NA	70 ^a	70 ^a	15 ^a	70 ^a
AT-Noncancer (day)	4380 ^a	NA	NA	NA	3285 ^a	25550 ^a	2190 ^a	365 ^a
AT-Cancer (day)	25550 ^a	NA	NA	NA	25550 ^a	25550 ^a	25550 ^a	25550 ^a
External radiation exposure								
DR (mrem/hr)	csv	NA	NA	NA	csv	csv	csv	csv
ET indoors (hr/day)	NA	NA	NA	NA	19.8 ^d	18.3 ^e	22 ^a	5 ^f
ET outdoors (hr/day)	4 ^d	NA	NA	NA	4.2 ^d	5.7 ^e	2 ^a	5 ^f
EF (day/yr)	52 ^d	NA	NA	NA	275 ^d	350 ^a	350 ^a	50 ^f
ED (yr)	12 ^d	NA	NA	NA	9 ^d	70 ^a	6 ^a	1 ^f
SH indoors (unitless)	NA	NA	NA	NA	0.5 ^a	0.5 ^a	0.5 ^a	0.5 ^a
SH outdoors (unitless)	0 ^a	NA	NA	NA	0 ^a	0 ^a	0 ^a	0 ^a
Ingestion of vegetables and fruit								
IR(fruit) x FI (g/day)	NA	42 ^a	NA	42 ^a	28 ^d	42 ^a	40 ^m	NA
IR(vegetables) x FI (g/day)	NA	80 ^a	NA	80 ^a	50 ^d	80 ^a	61.5 ^m	NA
EF (day/yr)	NA	350 ^a	NA	350 ^a	275 ^d	350 ^a	350 ^a	NA
ED (yr)	NA	70 ^a	NA	70 ^a	9 ^d	70 ^a	6 ^a	NA
BW (kg)	NA	70 ^a	NA	70 ^a	70 ^a	70 ^a	15 ^a	NA
AT-Noncancer (day)	NA	25550 ^a	NA	25550 ^a	3285 ^a	25550 ^a	2190 ^a	NA
AT-Cancer (day)	NA	25550 ^a	NA	25550 ^a	25550 ^a	25550 ^a	25550 ^a	NA

TABLE E.3-17
(Continued)

Pathway Parameters (units)	Trespassing Child Age 7-18	Off-Property RME Resident Adult Farmer Age 1-70	User of Meat & Milk Grown Within Operable Unit 1 Age 1-70	User of Great Miami River Water Age 1-70	On-Property CT Resident Adult Farmer Age 1-70	On-Property RME Resident Adult Farmer Age 1-70	On-Property RME Resident Child Age 1-6	On-Property Home Building Age 19+
Ingestion of meat, milk, and fish								
IR(meat) x FI (g/day)	NA	75 ^a	75 ^a	75 ^a	50 ^d	75 ^a	29 ^a	NA
IR(milk) x FI (L/day)	NA	0.3 ^a	0.3 ^a	0.3 ^a	0.2 ^d	0.3 ^a	0.9 ^a	NA
IR(fish) x FI (g/day)	NA	NA	NA	54 ^a	NA	NA	NA	NA
EF (day/yr)	NA	350 ^a	350 ^a	350 ^a	275 ^d	350 ^a	350 ^a	NA
ED (yr)	NA	70 ^a	70 ^a	70 ^a	9 ^d	70 ^a	6 ^a	NA
BW (kg)	NA	70 ^a	70 ^a	70 ^a	70 ^a	70 ^a	15 ^a	NA
AT-Noncancer (day)	NA	25550 ^a	25550 ^a	25550 ^a	3285 ^a	25550 ^a	2190 ^a	NA
AT-Cancer (day)	NA	25550 ^a	25550 ^a	25550 ^a	25550 ^a	25550 ^a	25550 ^a	NA

^aDOE 1992a, Risk Assessment Work Plan Addendum

^bNA - Not applicable

^cAssumes the RME works outdoors 2000 hours/year

^dEPA Region V

^eAssumes a resident small child spends 700 hours/year outdoor

^fAssumes a home builder spends 500 hours in one year building a home, spending 50% of his time working in/on the house, and 50% of the time working in/on the soil/waste (NRC 1985, Impacts BRC).

^gEPA 1992e, EPA/600/8-91/011b.

^hEPA 1992e, EPA/600/8-91/011b.

ⁱCSV - Chemical Specific Value

^jEPA 1992e, EPA/600/8-91/011b.

^kEPA 1992e, EPA/600/8-91/011b.

^lEPA 1992e, EPA/600/8-91/011b.

^mUSDA 1986, NFCS, CSFII Report No. 85-1.

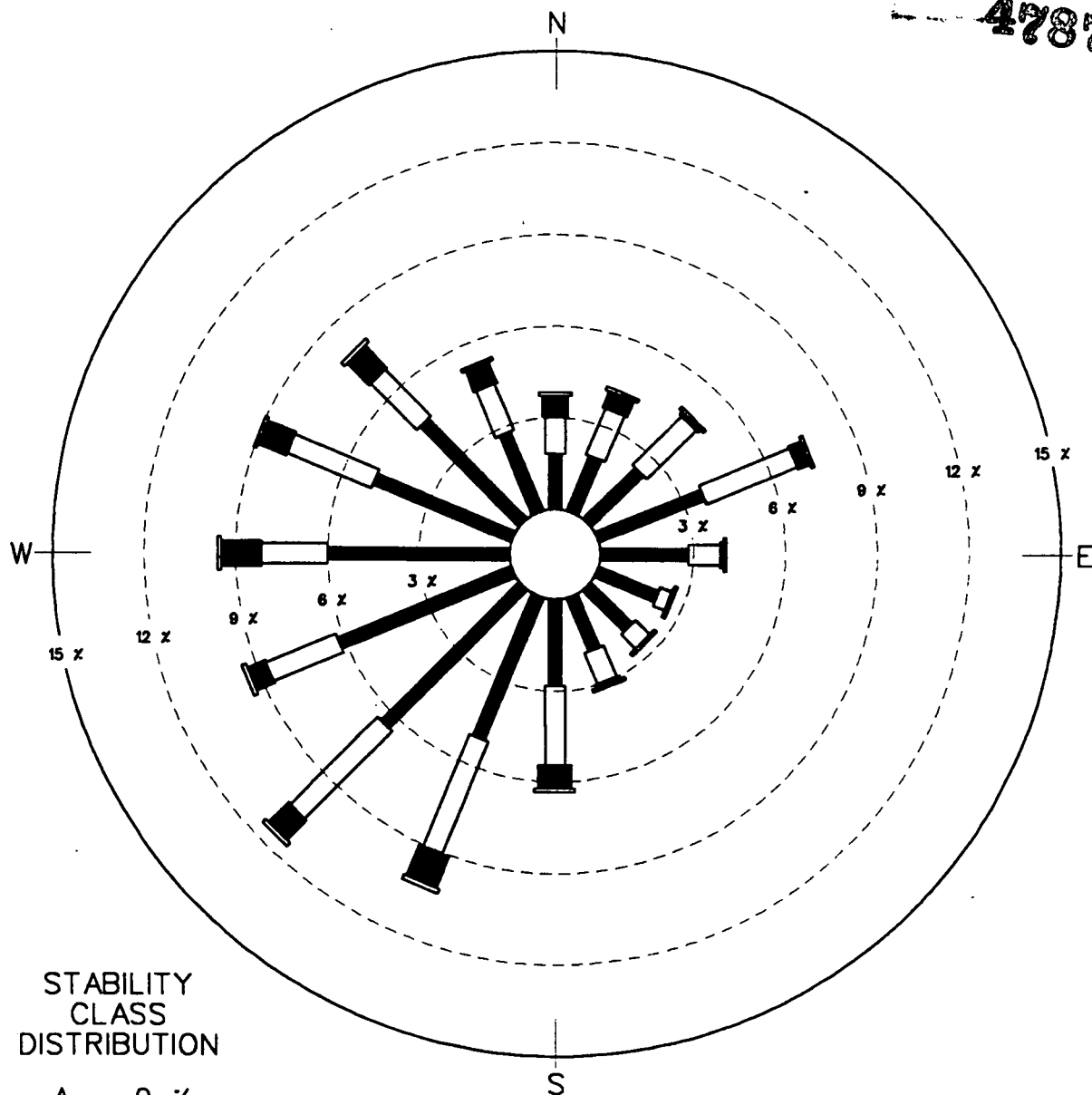
ⁿEPA, 1991f, RAGS, Part B.

^oEPA, 1992e, EPA/600/8-91/011b.

^pAdjusted based on 25% of waking hours spent on property, as per EPA Region V.

^qSee Section E.3.6.6.5.

4787



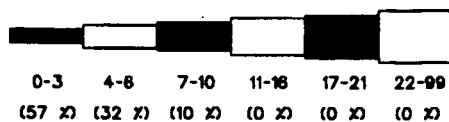
STABILITY CLASS DISTRIBUTION

A - 9 %
 B - 4 %
 C - 4 %
 D - 33 %
 E - 27 %
 F - 22 %

NOTES:

1. DIAGRAM OF THE FREQUENCY OF OCCURRENCE FOR EACH WIND DIRECTION. WIND DIRECTION IS THE DIRECTION FROM WHICH THE WIND IS BLOWING. EXAMPLE - WIND IS BLOWING FROM THE NORTH 4.8 PERCENT OF THE TIME.
2. RECORDED FROM A 33-FEET (10 METERS) TOWER DURING 1992.
3. SOURCE - RI OUA REPORT, 2-93, FIGURE E.1-11.

LEGEND:

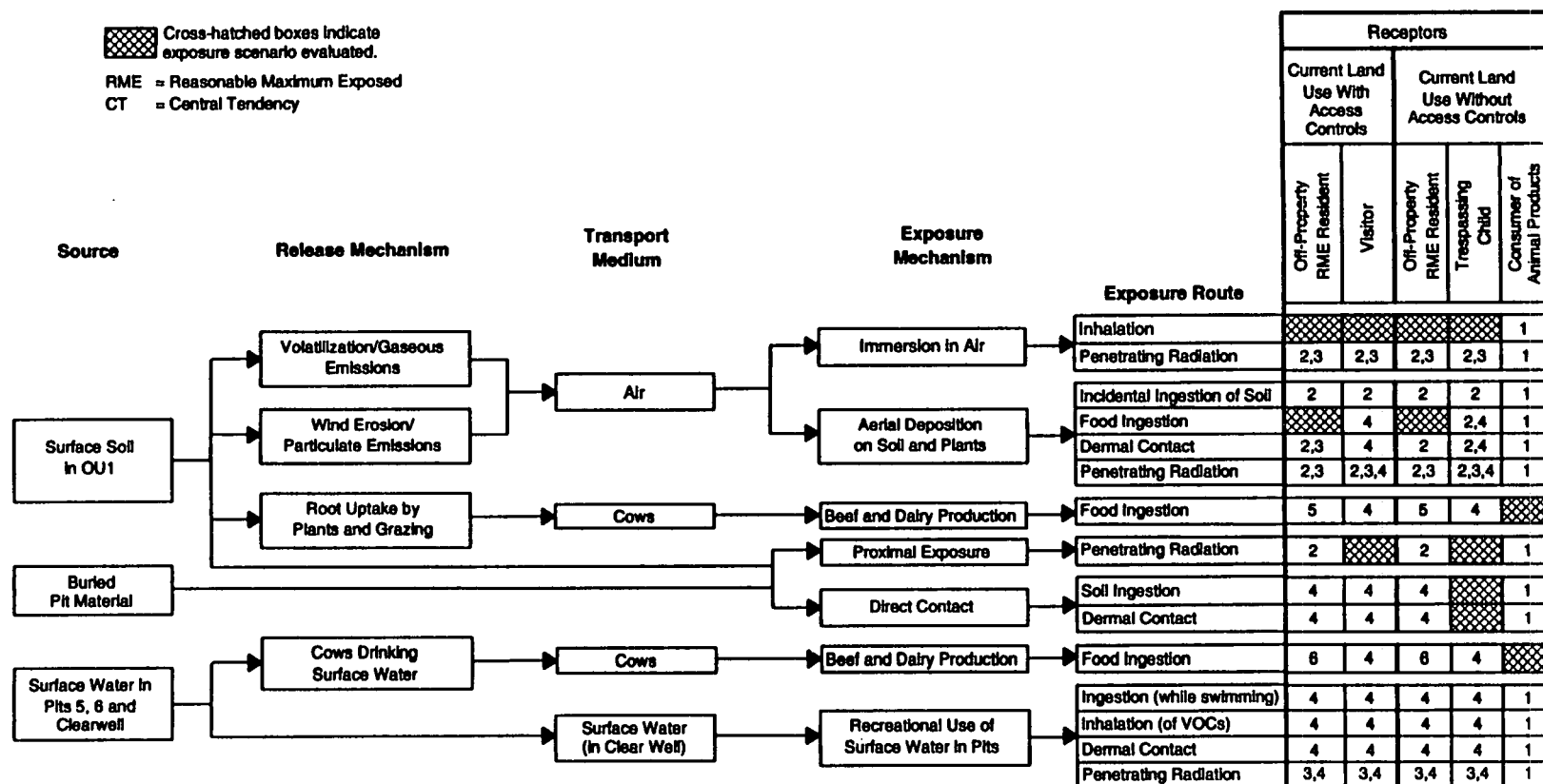


WIND SPEED SCALE (KNOTS)
 (1 KNOT EQUALS 1.15 MPH)

FIGURE E.3-1. WIND ROSE FOR THE FEMP SITE YEAR 1992

E-3-93

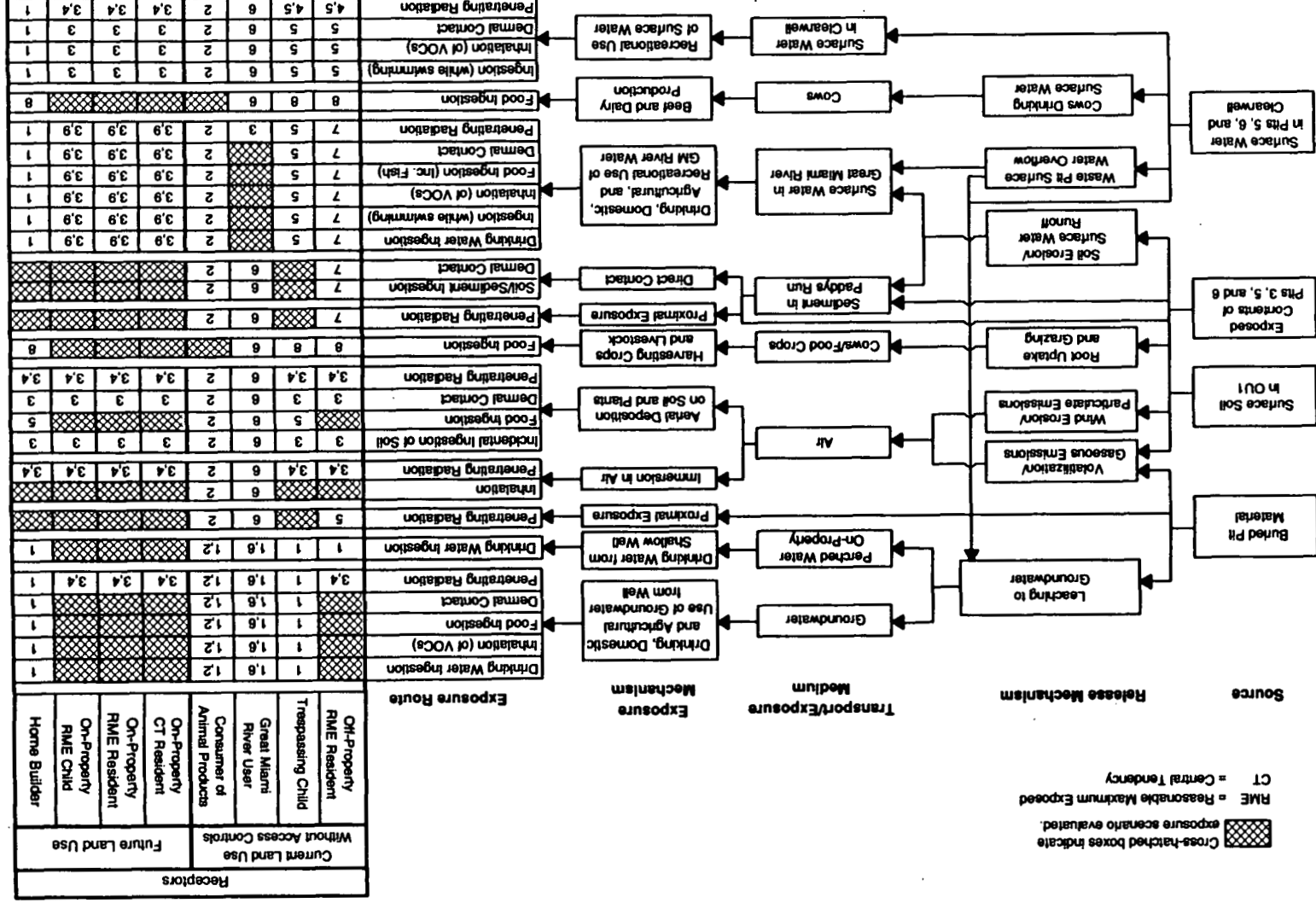
0547



- 1) The objective of quantifying risks to this receptor is to isolate and evaluate the impact of using meat and dairy products produced on-property.
- 2) Potential impact of exposure pathway is minor when compared to other exposure pathways for the same receptor.
- 3) EPA risk assessment methodology for radionuclides does not address this exposure route.
- 4) Exposure route not applicable to a transient or non-resident receptor. Exposures could be accidental.
- 5) This pathway is isolated and evaluated under the consumer of animal products scenario.
- 6) This receptor is assumed to obtain water for all needs from groundwater.

FIGURE E.3-2. CONCEPTUAL MODEL OF CURRENT SOURCE TERM CONFIGURATION

Cross-hatched boxes indicate exposure scenario evaluated.
 RME = Reasonable Maximum Exposed
 CT = Central Tendency



- 1) This receptor is assumed to obtain water for all needs from off-property sources.
- 2) This receptor is assumed to be a distant resident whose only mode of exposure is through consumption of meat and dairy products grown on the property.
- 3) Potential impact of exposure pathway is minor when compared to other exposure pathways for the same receptor.
- 4) EPA risk assessment methodology for radionuclides does not address this exposure route.
- 5) Exposure route not applicable to a transient or non-resident receptor. Exposures could be accidental.
- 6) This receptor is assumed to be a distant resident whose only mode of exposure involves using the Great Miami River.
- 7) The objective of quantifying risks to this receptor is to isolate and evaluate the impact of off-property exposures associated with farming.
- 8) This pathway is isolated and evaluated under the on-property grazing scenario.
- 9) It is assumed that residents living on the property rarely leave, so access to the Great Miami River would be very limited.

FIGURE E-3-3. CONCEPTUAL MODEL OF FUTURE SOURCE TERM CONFIGURATION

478

40891-A-338/ OUI / KNOX / DS
4089338.OUI 08/10/93 GP

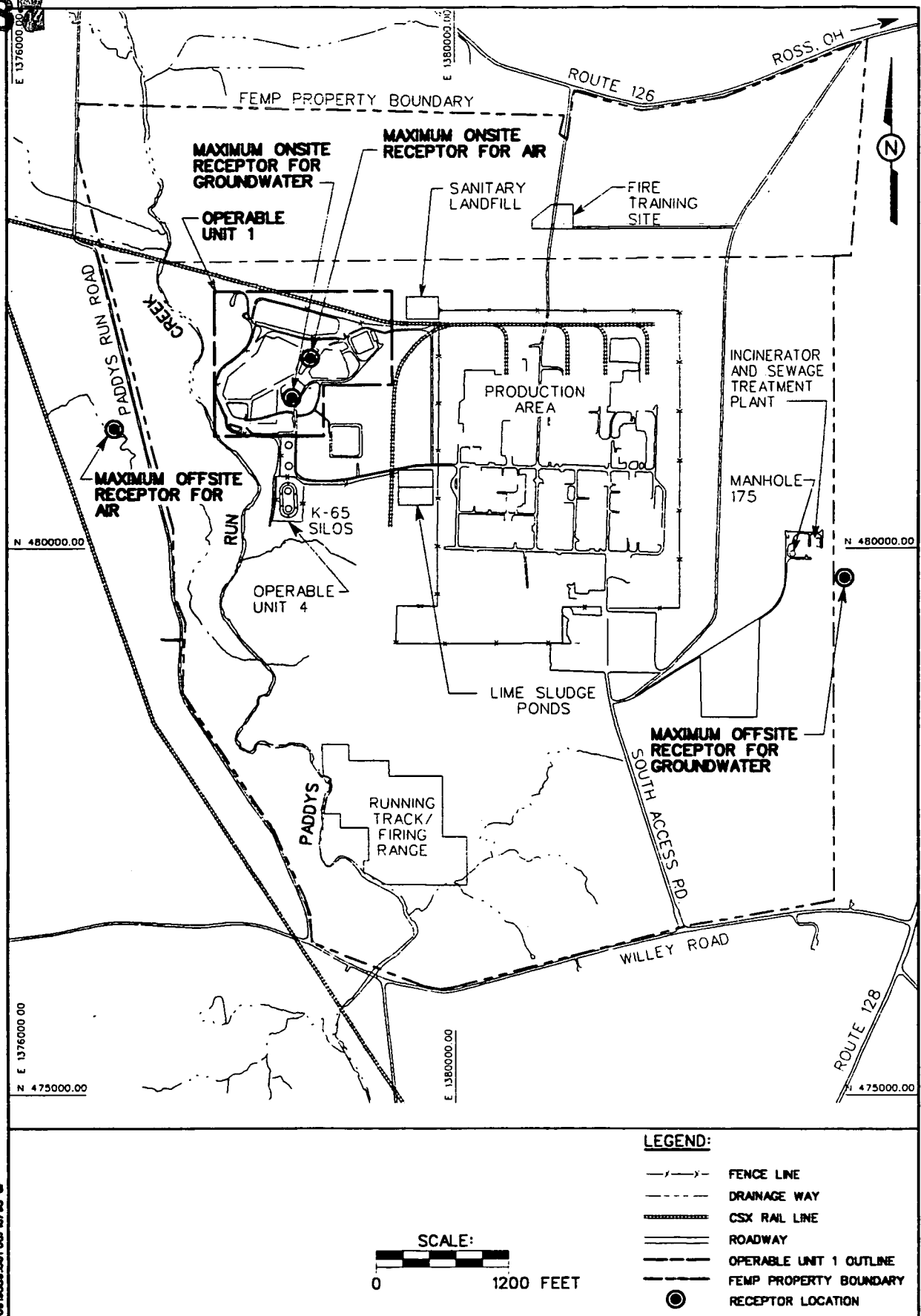


FIGURE E.3-4. RECEPTOR LOCATIONS USED TO EVALUATE AIR AND GROUNDWATER EXPOSURES FROM OUI

E.4.0 TOXICITY ASSESSMENT

This toxicity assessment examines information concerning the potential human health effects of exposure to constituents of potential concern (CPC) in the Operable Unit 1 Study Area. Its goal is to provide, for each listed constituent, a quantitative estimate of the relationship between the magnitude and type of exposure and the severity or probability of human health effects. The toxicity values derived in this section are integrated with the exposure assessment (Section E.3.0) to characterize the potential for adverse health effects to occur.

The toxicological evaluation involves a critical review and interpretation of toxicity data from epidemiological, clinical, animal, and in vitro studies. This review of the scientific data ideally determines both the nature of the health effects associated with a particular chemical, and the probability that a given quantity of a chemical could result in an adverse effect. This analysis defines the relationship between the dose received and the incidence of an adverse effect for those chemicals selected in Sections E.2.0 and E.3.0 of this Appendix.

The entire toxicological data base is used to guide the derivation of cancer slope factors (CSFs) for carcinogenic effects and reference dose (RfD) values for noncarcinogenic effects. This data may include epidemiological studies, long-term animal bioassays, short-term tests, and comparisons of molecular structure. Data from these sources are reviewed to determine if a chemical is likely to be toxic to humans. Due to the lack of available human studies, however, the majority of toxicity data used to derive cancer slope factors and reference dose values comes from animal studies.

For noncarcinogenic effects, the most appropriate animal model, i.e., the species biologically most similar to the human, is identified. Pharmacokinetic data often enter into this determination. In the absence of sufficient data to identify the most appropriate animal model, the most sensitive animal species is chosen. The RfD is generally derived from the most comprehensive toxicology study that characterizes the dose-response relationship for the critical effect of the chemical. Preference is given to studies using the exposure route of concern; in the absence of such data, however, an RfD for one route of exposure may be extrapolated from data from a study that used a different route of exposure. Such extrapolation must take into account pharmacokinetic and toxicological differences between routes of exposure. Uncertainty factors are applied to the highest no-observed adverse effect level (NOAEL) to adjust for inter- and intraspecies variation, deficiencies in the toxicological database, and use of subchronic rather than chronic animal studies. Additional uncertainty factors may be applied to estimate a NOAEL from a lowest observed adverse effect level (LOAEL) if the key study failed to determine a NOAEL. When chemical-specific data are not sufficient, an RfD may be derived from data for a chemical with structural and toxicologic similarity.

Cancer slope factors (CSFs) for weight-of-evidence Group A or B chemicals are generally derived from positive cancer studies that adequately identify the target organ in the test animal and characterize the dose-response relationship. CSFs are derived for Group C compounds for which the data are sufficient, but are not derived for Group D or E chemicals. No consideration is given to similarity in the animal and human target organ(s), because a chemical capable of inducing cancer in any animal tissue is considered potentially carcinogenic to humans. Preference is given to studies using the route of exposure of concern, in which normal physiologic function was not impaired, and in which exposure occurred during most of the animal's lifetime. Exposure and pharmacokinetic considerations are used to estimate equivalent human doses for computation of the slope factor. When a number of studies of similar quality are available, the data may be combined in the derivation of a slope factor.

Section E.4.1 presents the methodologies, assumptions, and sources of information used to perform the toxicity assessment for all Operable Unit 1 waste storage areas. An uncertainty analysis of the toxicity assessment is presented in Section E.4.2. Toxicological summaries for CPCs identified in Section E.2 are included in Section E.4.3.

E.4.1 TOXICITY INFORMATION FOR CONTAMINANTS OF POTENTIAL CONCERN

Certain chemical and radiological constituents found in Operable Unit 1 wastes are known or potential carcinogens in humans. It is generally assumed in health risk assessment that any dose of a carcinogen may result in cancer induction. The EPA assumes that a small number of molecular events can cause single-cell changes that can lead to uncontrolled cellular proliferation. This "nonthreshold" hypothesis assumes there is essentially no level of exposure that does not pose some level of carcinogenic risk.

As pointed out in EPA 1989a, certain fundamental differences exist between radionuclides and chemicals that somewhat simplify toxicity assessment for radionuclides. Because of these differences, the carcinogenic effects of radiation and chemicals are presented separately.

E.4.1.1 Radiocarcinogens

Some elements have isotopes consisting of unstable atoms (i.e., they undergo spontaneous transformation into more stable atoms). These isotopes are said to be radioactive, and the transformation process is known as radioactive decay. Radioactive decay is usually accompanied by the emission of charged particles and gamma rays. These emissions are called radiation. There are three types of radiation, which are potentially of concern at the FEMP: alpha, beta, and gamma. Alpha and beta radiation consist of charged particles capable of ionizing nearby matter. These radiations generally have little ability to penetrate deeply into adjacent matter, and can be interdicted by skin, air, and clothing. In most cases, the emission of an alpha or beta particle from an atom is followed by a release of x-rays or gamma radiation. Depending on their energies, these radiations may

have considerably more penetration power than either alpha or beta radiation and are thus more difficult to shield.

Radiation exposures can be separated into external and internal exposures. External exposure occurs when the radionuclide is outside of the body. Because alpha and beta radiation generally have a low penetrating power, skin and air become effective radiation shields in most cases. Therefore, external exposures to gamma radiation are the primary concern at environmental levels. Internal exposure occurs after the radionuclide enters the body via inhalation or ingestion. For internal exposures, alpha and beta particles become more important because their energy is directly absorbed by living cells.

Inhalation and ingestion are the primary routes for internal exposure to radionuclides. Biologically significant exposures to alpha and beta emitters are more probable for internal exposure because the emitter is in direct contact with tissue. Once in the body, exposure depends on the absorption and retention characteristics of the radionuclide. These absorption and retention characteristics are based on the chemical form of the radionuclide in a compound and not on the isotopic form of the radionuclide. GI absorption factors and lung retention classifications for the radionuclides of concern are presented in Table E.4-1.

Radioactive contamination within Operable Unit 1 is characterized as low-level ionizing radiation. The principal adverse biological effects associated with ionizing radiation from radioactive substances in the environment are mutagenicity, teratogenicity, and carcinogenicity. Mutagenicity is the ability to induce genetic mutations in the nuclei of either body cells or reproductive cells. Teratogenicity is the ability to induce or increase the incidence of congenital malformations, which are permanent structural or functional deviations produced during embryonic growth and development. Carcinogenicity is the ability to produce cancer. The carcinogenicity of a radioactive isotope of an element depends on several factors including:

- The type of radiation emitted by the radioisotope
- The energy of the radiation emitted
- The radiological half-life of the isotope
- The retention and concentration characteristics of the radioisotope in the human body

Carcinogenicity is believed to be the limiting deleterious effect at the levels of radiation dose encountered within Operable Unit 1 and has been used as the sole basis for assessing the radiation-related human health risks of a site contaminated with radionuclides (EPA 1989a).

The relationship between radiation dose and health effects is relatively well characterized for high doses (i.e. >10 rad). Hence, risk estimates are strictly applicable only to large populations exposed to high levels of radiation. Lower levels of exposure may constitute a health risk, but a direct cause and effect relationship is difficult to establish because a particular effect in a specific individual can be

produced by many different processes. For low doses, health effects are presumed to occur but can only be estimated statistically. Therefore, the risk of cancer incidence from exposure to low levels of ionizing radiation must be extrapolated from incidence data at higher doses.

Under CERCLA methodology, the EPA assumes a unit intake of, or external exposure to, a radionuclide over a lifetime. The annual radiation dose equivalent from the radionuclide to each organ in each year of life is calculated. The average excess number of all types of radiation-induced fatal cancers that occur in a year is then estimated for the corresponding dose equivalents received during that year and relevant preceding years. The excess number of radiation-induced fatal cancers is derived from epidemiological data, extrapolation from high radiation doses to low doses, and hypothetical models for projecting risk through a lifetime. The relationship between cancer incidence and exposure to radioactive materials is quantified by using mathematical extrapolation models, which estimate the largest possible linear slope (within the 95 percent confidence limit) at low extrapolated doses consistent with the data. Because EPA is concerned with assessing cancer incidence, each radionuclide slope factor has been calculated by dividing the excess fatal cancer risk for that radionuclide by the mortality-to-incidence risk ratio (EPA 1989a) for the types of cancer induced by that radionuclide. This "radiocarcinogenicity slope factor" thus is characterized as the "maximum likelihood estimate of the age-averaged lifetime total excess cancer risk per unit intake or exposure" (EPA 1991b). That is, the true risk to humans, although not identifiable, is not likely to exceed this upperbound estimate; it may, in fact, be lower.

The EPA Office of Radiation Programs (ORP) has calculated cancer slope factors for radionuclides of potential concern at Superfund sites. These values are listed in EPA's *Health Effects Assessment Summary Tables* (HEAST, Table C) (EPA 1991b; EPA 1992b) and are presented as the risk of cancer incidence per unit intake of a radionuclide contaminant. The radionuclide slope factors used in this assessment are expressed in units of pCi^{-1} or g/pCi_y and are presented in Table E.4-1.

E.4.1.2 Chemical Carcinogens

The toxicity information considered in the assessment of potential carcinogenic risks includes (1) a weight-of-evidence classification and (2) a slope factor. The weight-of-evidence classification qualitatively describes the likelihood that a chemical is a human carcinogen and is based on an evaluation of the available data from human and animal studies. A chemical may be placed in one of three groups in EPA's classification system to indicate its potential for carcinogenic effects: Group A, a human carcinogen; Group B1, or B2, a probable human carcinogen; and Group C, a possible human carcinogen. Chemicals that cannot be classified as human carcinogens because of a lack of data are placed in Group D, and those for which there is evidence of noncarcinogenicity in humans are placed in Group E.

The cancer slope factor is the toxicity value used to quantitatively express the carcinogenic hazard of cancer-causing constituents. It is defined as the upper-bound estimate of the probability of cancer incidence per unit dose averaged over a lifetime. Slope factors are derived from studies of carcinogenicity in humans and/or laboratory animals and are typically calculated for compounds in Groups A, B1, and B2. Slope factors are specific to a chemical and route of exposure and expressed in units of $(\text{mg/kg/day})^{-1}$ for both oral and inhalation routes. The induction of cancer by dermal absorption is evaluated using oral slope factors. Inhalation cancer toxicity values are usually expressed as inhalation unit risks in units of reciprocal $\mu\text{g}/\text{m}^3$ ($1/\mu\text{g}/\text{m}^3$). Because cancer risk characterization requires an estimate of reciprocal dose in units of $1/\text{mg/kg-day}$, the inhalation unit risk must be converted to the mathematical equivalent of an inhalation cancer slope factor, or risk per unit dose (mg/kg-day). This is done by assuming humans weigh 70 kg and inhale 20 m^3 of air/day, i.e., the inhalation unit risk ($1/\mu\text{g}/\text{m}^3$) divided by $20 \text{ m}^3/\text{day}$, multiplied by 70 kg and multiplied by 1000 $\mu\text{g}/\text{mg}$ yields the mathematical equivalent of an inhalation slope factor ($1/\text{mg/kg-day}$). Slope factors for chemical constituents are presented in Table E-4-2. The primary sources of these toxicity values are EPA's *Integrated Risk Information System (IRIS)* (EPA 1993a) and the quarterly updated HEAST (EPA 1992b). Other EPA sources of cancer slope factors were also consulted when available. Surrogate chemicals were not used for cancer slope factor derivation unless the chemical similarity was very close and the derivation was highly defensible.

The following exceptions, where information from one chemical was used to model a compound class, are noted:

- The carcinogenicity of all polychlorinated biphenyl (PCB) isomers is assumed to be equal to the carcinogenicity of Aroclor-1260 because dose-response data for other isomers are inconclusive.
- The carcinogenicity of dioxins and furans are determined using EPA's revised 1989 "Toxicity Equivalency Factors" (TEFs) (EPA 1990d). These TEFs were determined with the basic assumption that all dioxins and furans are carcinogenic.
- The carcinogenicity of PAHs is determined initially using the benzo(a)pyrene cancer slope factors, and refined using a relative potency approach (Clement 1988, 1990).

For risk assessment purposes, mixtures of chlorinated dibenzo-p-dioxins (CDDs) and chlorinated dibenzofurans (CDFs) can be evaluated using EPA's toxicity equivalency method. This approach, based on available toxicological data, uses derived TEFs to convert the concentration of CDD or CDF congeners into an equivalent concentration of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). Table E-4-3 presents the TEFs for a variety of CDD and CDF congeners. Congeners containing chlorines at the 2,3,7, and 8 positions are considered to be more toxic, and congeners without chlorines at those positions are assigned a TEF of "0." However, to be more conservative, all unspecified congeners are assumed to be the more toxic form.

Carcinogenic risks associated with PAHs are evaluated using the relative potency approach described by Clement (1988 and 1990). This approach, approved by EPA Region V, considers the relative potency of the individual PAHs and allows site-specific relative concentrations to be expressed in the risk assessment. The relative potency factors for PAHs are presented in Table E.4-4.

E.4.1.3 Noncarcinogenic Chemicals

For noncarcinogens, it is assumed that a dose exists below which no adverse health effects will be seen. Below this "threshold" dose, exposure to a chemical can be tolerated without adverse effects. For noncarcinogens, a range of exposure exists that can be tolerated without adverse effects. Toxic effects are manifested only when physiologic protective mechanisms are overcome by exposures to a constituent above its threshold level. Maternal and developmental endpoints are considered systemic toxicity.

The potential for noncarcinogenic health effects resulting from exposure to chemical contaminants is assessed by comparing an exposure estimate (intake) to a reference dose (RfD). The RfD is expressed in units of mg/kg/day and represents a daily intake of contaminant per kilogram of body weight that is not sufficient to cause the threshold effect of concern for the contaminant. An RfD is specific to the chemical, the route of exposure, and the duration over which the exposure occurs. Separate RfDs are presented for ingestion and inhalation pathways. EPA (1992b) presents reference concentrations (RfCs) for the inhalation route. Inhalation noncancer toxicity values are usually expressed as inhalation concentrations (RfCs) in units of mg/m³. Because noncancer risk characterization requires an estimate of dose in units of mg/kg-day, the inhalation RfC must be converted to an inhalation RfD. This is done by assuming humans weigh 70 kg and inhale 20 m³ of air per day (i.e., the inhalation RfC (mg/m³) multiplied by 20 m³/day and divided by 70 kg yields an inhalation RfD (mg/kg-day). To derive an RfD, the EPA reviews all relevant human and animal studies for each compound and selects the study (studies) pertinent to the derivation of the specific RfD. Each study is evaluated to determine the no-observed-adverse-effect level (NOAEL) or, if data are inadequate for such a determination, the lowest-observed-adverse-effect level (LOAEL). The NOAEL corresponds to the dose, in mg/kg-d that can be administered over a lifetime without inducing observable adverse effects. The LOAEL corresponds to the lowest daily dose, in mg/kg-d, that can be administered over a lifetime that induces an observable adverse effect. The toxic effect characterized by the LOAEL is referred to as the "critical effect". To derive an RfD, the NOAEL (or LOAEL) is divided by uncertainty factors to ensure that the RfD will be protective of human health. Uncertainty factors are applied to account for (1) extrapolation of data from laboratory animals to humans (interspecies extrapolation), (2) variation in human sensitivity to the toxic effects of a compound (intraspecies differences), (3) derivation of a chronic RfD based on a subchronic rather than a chronic study, and/or (4) derivation of an RfD from the LOAEL rather than the NOAEL. In addition to these uncertainty factors, modifying factors between 0 and 10 may be applied to reflect additional qualitative considerations in evaluating the data. For most compounds, the modifying factor is 1.

Reference doses for noncarcinogenic CPCs are presented in Table E.4-2. The primary source of values for reference doses is IRIS, an on-line database that contains current health risk and regulatory information for many chemicals (EPA, 1993a). The RfDs and RfCs are also tabulated in HEAST (EPA, 1992b). Other EPA sources of provisional RfD values were also consulted when available. Surrogate chemicals were not used for derivation of an RfD unless the chemical similarity was very close and the derivation was highly defensible.

E.4.1.4 Dermal Reference Doses and Cancer Slope Factors

Dermal RfD values and cancer slope factors are derived from the corresponding oral values. In the derivation of a dermal RfD, the oral RfD is multiplied by the gastrointestinal (GI) absorption factor, expressed as a fraction. The resulting dermal RfD is an RfD based on absorbed dose, which is the appropriate value with which to compare a dermal dose, because dermal doses are expressed as absorbed rather than exposure doses. In a similar manner, and for the same reasons, a dermal cancer slope factor is derived by dividing the oral cancer slope factor by the GI absorption efficiency. The oral slope factor is divided, rather than multiplied, by the GI absorption efficiency because cancer slope factors are expressed as reciprocal dose. Dermal RfD values and cancer slope factors for the chemicals of concern in Operable Unit 1 are presented in Table E.4-5.

The most important consideration regarding the uncertainty associated with a dermal RfD or cancer slope factor is the accuracy of the GI absorption efficiency factor. For this reason, the toxicity profiles presented in Section E.4.3 contain pharmacokinetics sections in which the oral absorption data are evaluated. Where appropriate, the low (most conservative) end of the range of available GI absorption data for humans is used in the derivation of the dermal RfD or cancer slope factor. When the human data are insufficient, animal data are used. Data from high-dose experiments are not used if more suitable data are available and it appears that saturation of the GI absorption process could have occurred.

When sufficient quantitative data were not located, a default GI absorption factor was used. As noted by EPA (1989a), the GI absorption of many metals from the GI tract is limited, and 0.05 is a reasonable default for metals and inorganic substances.

EPA (1989a) did not recommend a separate default value for organic chemicals. A compilation of data for 19 organic chemicals presented GI absorption efficiencies ranging from 0.5 to 1.0. All but 3 of the 19 chemicals had GI absorption efficiencies of at least 0.9, indicating that organic chemicals are generally readily absorbed. The arithmetic average of the GI efficiencies for the 19 organic chemicals, 0.91368, equivalent to 0.9 when rounded to one significant figure, appears to be a reasonable default GI absorption efficiency factor for organic chemicals. The default of 0.9 for GI absorption is used for organic chemicals for which quantitative data were not sufficient. The GI

0554

efficiency factors used to derive the dermal RfD values and cancer slope factors are presented in Table E.4-5.

Table E.4-6 contains information on several chemical properties used in the estimation of dermal intakes. These parameters serve as input to dermal exposure equations presented in Section E.3.

E.4.2 UNCERTAINTY ANALYSIS FOR TOXICITY ASSESSMENT

Considerable uncertainty is associated with the qualitative (hazard assessment) and quantitative (dose-response) evaluations of a Superfund-type risk assessment. The hazard assessment deals with characterizing the nature and strength of the evidence of causation, or the likelihood that a chemical that induces adverse effects in animals will induce adverse effects in humans.

Uncertainty in hazard assessment arises from the nature and quality (sensitivity and selectivity) of the animal and human data. Uncertainty is decreased when similar effects are observed across species, strain, sex, and exposure route; when the magnitude of the response is clearly dose-related; when pharmacokinetic data indicate a similar fate of the chemical in animals and humans; when postulated mechanisms of toxicity are similar for humans and animals; and when the CPC is structurally similar to other chemicals for which the toxicity is more completely characterized.

Hazard assessment of carcinogenicity is evaluated as a weight-of-evidence determination, using either the IARC (1987) or EPA (1986b) schemes. The Operable Unit 1 Assessment uses the EPA scheme. Positive animal cancer test data suggest that humans contain tissue(s) that may also manifest a carcinogenic response; however, the animal data cannot necessarily be used to predict the target tissue in humans. Animal data, however, are usually obtained from studies performed with high doses that exceed expected human environmental doses by several orders of magnitude. Recent evaluations indicate that physiologic phenomena that result in cancer in animals exposed to high doses probably do not operate in humans exposed to environmental doses (Gold et al., 1992). A prime example is the occurrence of liver tumors in mice exposed to high levels of chlorinated organic compounds (e.g., chlordane, carbon tetrachloride and DDT, which are CPCs for Operable Unit 1) (Gold et al., 1992; Scala, 1991). This introduces serious doubt regarding the potential carcinogenicity to humans of many of the chemicals currently classified in weight-of-evidence Group B2 or C. Therefore, the consideration of Group B2 and C chemicals as potential human carcinogens is an extremely biased and conservative approach that introduces a great deal of uncertainty into the carcinogenicity assessment.

In the hazard assessment of noncancer effects, however, positive animal data suggest the nature of the effects (i.e., the target tissues and type of effects) anticipated in humans (EPA 1989i). Therefore, less uncertainty is associated with the noncarcinogenic effects than is associated with the carcinogenicity of chemicals. This is intuitively reasonable, because it is well established that extremely high doses of virtually any chemical will eventually induce some kind of adverse effect. For noncarcinogens,

therefore, the greater uncertainty is associated with the quantitative, rather than with the qualitative assessment.

There are many sources of uncertainty in the dose-response evaluation for cancer (i.e., computation of a slope factor or unit risk) and noncancer effects (i.e., computation of an RfD or RfC). One type of uncertainty is related to interspecies (animal-to-human) extrapolation, which, in the absence of quantitative pharmacokinetic, dosimetric, or mechanistic data, is usually based on consideration of interspecies differences in basal metabolic rate. Another source of uncertainty is intraspecies, or individual, variation. Most toxicity experiments are performed with animals that are very similar in age and genotype, so that intragroup biological variation is minimal, but the human population of concern may reflect a great deal of heterogeneity, including a small number of persons with unusual sensitivity to the CPC. Even toxicity data from human occupational exposure reflect a bias because only those individuals sufficiently healthy to attend work regularly and those not unusually sensitive to the CPC are likely to be occupationally exposed. Uncertainty also arises from the quality of the key study (from which the quantitative estimate is derived) and the database. For cancer effects, the uncertainty associated with some quality factors (e.g., group size) is expressed within the 95 percent upper bound of the slope factor. For noncancer effects, additional uncertainty factors may be applied in the derivation of the RfD or RfC to reflect poor quality of the key study or gaps in the database. This technique tends to greatly overestimate the toxicity of a chemical.

Another source of uncertainty regarding quantitative risk estimation for carcinogenicity is the method by which data from high doses in animal studies are extrapolated to the dose range expected for environmentally exposed humans. The linearized multistage model, which is used in nearly all quantitative estimations of human risk from animal data, is based on a nonthreshold assumption of carcinogenesis. An impressive body of evidence, however, suggests that epigenetic carcinogens, as well as many genotoxic carcinogens, have a threshold below which they are noncarcinogenic (Gold et al., 1992; Williams and Weisburger 1991); therefore, the use of the linearized multistage model is extremely conservative for chemicals that exhibit a threshold for carcinogenicity.

A further source of uncertainty for noncancer effects arises from use of an effect level in the estimation of an RfD or RfC, because this estimation is predicated on the assumption of a threshold below which adverse effects are not expected. Therefore, an additional uncertainty factor is usually applied to estimate a no-effect level. Additional uncertainty arises from estimation of an RfD or RfC for chronic exposure from less than chronic data. Unless empirical data indicate that effects do not worsen with increasing duration of exposure, an additional uncertainty factor is applied to the no-effect level in the less than chronic study. The overall effect of all the uncertainty factors (for inter- and intraspecies variation, duration of study, estimation of no-adverse-effect level, deficiencies of the overall toxicologic data base) is to produce a quantitative estimate (RfD) that is extremely conservative.

As an example of these types of uncertainty, we consider the toxicity information for uranium. Uranium as an alpha particle emitter is considered a carcinogen; however, epidemiological evidence of uranium-induced excess cancer risks are very difficult to obtain. This is largely because the human data available for radiocarcinogenic effects of uranium exposure are for underground miners, who are also simultaneously exposed to radon and radon progeny as a confounding factor. The studies of humans usually lack quantitative information concerning uranium exposure, potential uranium exposure through previous employment, concurrent smoking patterns, or concurrent radon exposure levels that are needed to more definitively determine the risk attributable solely to uranium exposure. The human studies of cancer from exposure to uranium frequently reveal a slight excess risk (if any) above the natural risk. These confounding factors weaken the power of the human studies to detect any excess risk. These uncertainties are not well known or easily quantified.

The toxicity information used in the Operable Unit 1 assessment also introduces some uncertainty relative to the following:

- The carcinogenicity of all PCB mixtures are assumed to be equal to the carcinogenicity of Aroclor-1260, because dose-response data for other mixtures are inconclusive or negative. The only PCB mixture with positive carcinogenicity results is Aroclor-1260. Statistically significant cancer results were not seen for aroclors with lower percentages of chlorination.
- All chromium is assumed to be in the form of hexavalent chromium, which is the more toxic/carcinogenic form of this metal.
- The carcinogenicity of dioxins and furans are determined using EPA's revised 1989 Toxicity Equivalency Factors (TEFs) (EPA 1990d). These TEFs were determined with the basic assumption that all dioxins and furans are carcinogenic. Conservatism is built into the evaluation of risks from dioxins/furans.
- The assumption that arsenic is carcinogenic via ingestion is a conservative approach. No ingestion slope factor has been approved by the EPA.

A significant source of uncertainty for calculating risks from radionuclides in surface soil is the use of EPA slope factors for external radiation exposure. In deriving these slope factors, EPA has assumed that an individual continuously stands on an infinitely thick slab of soil with a uniform radionuclide concentration. To manage complicated calculations for photon attenuation and scattering in soil, EPA has assumed that the activity in the slab source is present on an infinite plane with uniform surface concentration. The slope factors for external radiation exposure are, therefore, based on calculated exposures (and associated risks of cancer incidence) from the hypothetical plane source.

In addition, EPA calculates slope factors for ingestion of many radionuclides using the maximum value for the GI absorption factor. The actual chemical form(s) that influence the magnitude of the GI absorption factor have not been considered.

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0557

In summary, the major sources of uncertainty associated with the toxicity assessment, including their relative magnitude and direction of bias, are as follows:

- Hazard assessment of carcinogens--very large, extremely positive bias for Group B and Group C chemicals
- Hazard assessment of noncarcinogenic effects--not large; virtually any chemical will eventually induce some kind of adverse effect at high doses for a long duration of exposure
- Quantitative assessment of carcinogens--very large, extremely positive bias for direct exposure and ingestion of radionuclides, and particularly for chemicals whose primary mechanism of action is epigenetic
- Quantitative assessment of noncarcinogenic effects--large, positive bias, particularly for chemicals for which the RfD derivation required a large uncertainty factor

E.4.3 TOXICITY PROFILES

This subsection presents more detailed toxicity information for individual CPCs as well as for the other compounds identified at OU1. This information includes summary descriptions of toxicity, based on critical studies used as a basis for the toxicity value; toxic effects resulting from chronic exposure; and the critical toxic effect observed or target organ affected. Profiles of chemicals are arranged in alphabetical order.

E.4.3.1 Acenaphthylene

E.4.3.1.1 Noncancer Toxicity

Noncancer toxicity data were not located for acenaphthylene, but the chemical is structurally very similar to acenaphthene. Acenaphthene appears to be a mild hepatotoxicant, and possibly a nephrotoxicant, in rodents (EPA 1993a). It is reasonable to suspect that acenaphthylene may induce similar effects.

E.4.3.1.2 Carcinogenicity

The EPA (1993a) classifies acenaphthylene as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans), based on no human cancer data and inadequate cancer data in animals. The animal data consist of an inadequately reported lifetime skin painting study in which skin tumors were not observed in mice treated with acenaphthylene (Cook 1932). Tumors were observed in mice treated with other PAHs.

E.4.3.2 Acetone

E.4.3.2.1 Noncancer Toxicity

Studies of workers exposed to acetone revealed irritation of the ocular and respiratory tract mucosa, and, at high concentrations, central nervous system (CNS) effects (American Conference of Governmental Industrial Hygienists [ACGIH] 1991). Rats exposed by inhalation to high concentrations exhibited narcosis and slight decreases in organ and body weight, compared with controls, but no clinical pathological or histopathological evidence of organ damage. Inhalation reference concentration (RfC) values were not located for acetone. Oral toxicity data are limited to a comprehensive 90-day gavage study in rats, in which 100 mg/kg/day was a no observed effect level (NOEL) and 500 mg/kg/day was the lowest observed adverse effect level (LOAEL) associated with increased liver and kidney weight and tubular nephropathy (EPA 1993a). A verified RfD for chronic oral exposure of 0.1 mg/kg/day was derived by applying an uncertainty factor of 1000 to the NOEL of 100 mg/kg/day. The EPA (1992b) presented a provisional subchronic oral RfD of 1 mg/kg/day, based on the same NOEL and an uncertainty factor of 100. The target organs for inhalation exposure to acetone are the CNS and the respiratory and ocular mucosa. Target organs for oral exposure are the liver and kidney.

E.4.3.2.2 Carcinogenicity

Acetone is classified as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans) based on a lack of human or animal carcinogenicity data (EPA 1993a).

E.4.3.3 Ammonia

E.4.3.3.1 Noncancer Toxicity

Ammonia is produced naturally as an end product of protein metabolism (Sax and Lewis 1987). Ammonia excreted in expired air may arise from the bacterial action in the mouth (EPA 1993a). Nasal and throat irritation are consistent findings in humans exposed to ≥ 50 parts per million (ppm) in the air (Ferguson et al. 1977). No significant increase in ocular, dermal, or respiratory irritation was reported by workers, and no decrement in lung function was measured in workers exposed to a time weighted average (TWA) concentration of 9.2 ppm (Holness et al. 1989). Lung function tests, however, may not be the most sensitive indicators of ammonia toxicity, as explained below.

In animals exposed to ≤ 500 ppm, lesions including irritation and hyperplasia were restricted to the upper respiratory tract (Gamble and Clough 1976; Flury et al. 1983; EPA 1993a). At these concentrations, virtually the entire inhaled dose was taken up by the upper respiratory mucosa because of the high solubility and reactivity of ammonia. At higher concentrations, ammonia penetrated to the lungs and induced congestion, edema, and hemorrhage (Anderson et al. 1964). Congestion of the spleen and liver may arise from ammonia-induced impairment of pulmonary circulation.

The EPA (1993a) derived an RfC of 0.1 milligram per cubic meter (mg/m^3) for chronic inhalation exposure to ammonia, based on the no observed adverse effect level (NOAEL) of 9.2 ppm ($6.4 \text{ mg}/\text{m}^3$) in the occupational study previously described. An uncertainty factor of 30 was applied, 10 to provide protection for sensitive individuals and 3 to account for deficiencies in the database, including lack of chronic data, proximity of the human NOAEL to an animal LOAEL, and lack of reproductive and developmental data. Confidence in the RfC was medium.

E.4.3.3.2 Carcinogenicity

The EPA (1993a) has not evaluated the carcinogenicity of ammonia.

E.4.3.4 Antimony

E.4.3.4.1 Pharmacokinetics

Ingested antimony is absorbed slowly and incompletely from the gastrointestinal (GI) tract (Iffland 1988). Within a few days of acute exposure, highest tissue concentrations are found in the liver, kidney, and thyroid. Organs of storage include skin, bone, and teeth. Highest concentrations in deceased smelter workers (inhalation exposure) occurred in the lungs and skeleton. Excretion is largely via the urine or feces, although some is incorporated into the hair.

E.4.3.4.2 Noncancer Toxicity

Acute intoxication from ingestion of large doses of antimony induces GI disturbances, dehydration, and cardiac effects in humans (Iffland 1988). Chronic effects from occupational exposure include irritation of the respiratory tract, pneumoconiosis, pustular eruptions of the skin called "antimony spots," allergic contact dermatitis, and cardiac effects, including abnormalities of the electrocardiograph (ECG) and myocardial changes. Cardiac effects were also observed in rats and rabbits exposed by inhalation for six weeks and in animals (dogs, and possibly other species) treated by intravenous injection (Elinder and Friberg 1986a).

Chronic oral exposure studies in laboratory animals include two briefly reported lifetime drinking water studies in rats and mice (Kanisawa and Schroeder 1969; Schroeder et al. 1970). The only dose tested, 5 ppm potassium antimony tartrate, resulted in reduced longevity in both species and in reduced mean heart weight in the rats. The EPA (1993a) verified an RfD of $0.0004 \text{ mg}/\text{kg}/\text{day}$ for chronic oral exposure to antimony from the LOAEL of 5 ppm potassium antimony tartrate ($0.35 \text{ mg antimony}/\text{kg body weight}\cdot\text{day}$) in the lifetime study in rats (Schroeder et al. 1970). An uncertainty factor of 1000 was applied; factors of 10 each for inter- and intraspecies variation and to estimate an NOAEL from an LOAEL. The heart is considered a likely target organ for chronic oral exposure of humans.

4787

E.4.3.4.3 Carcinogenicity

Data were not located regarding the carcinogenicity of antimony to humans. Antimony fed to rats did not produce an excess of tumors (Goyer 1991), but a high frequency of lung tumors was observed in rats exposed by inhalation to antimony trioxide for one year (Elinder and Friberg 1986). Antimony is classified in EPA cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans) (EPA 1987a).

E.4.3.5 Arsenic

E.4.3.5.1 Pharmacokinetics

Several studies confirm that soluble inorganic arsenic compounds and organic arsenic compounds are almost completely (>90 percent) absorbed from the GI tract in both animals and humans (Ishinishi et al. 1986). The absorption efficiency of insoluble inorganic arsenic compounds depends on particle size and stomach pH. Initial distribution of absorbed arsenic is to the liver, kidneys, and lungs, followed by redistribution to hair, nails, teeth, bone, and skin, which are considered tissues of accumulation. Arsenic has a longer half-life in the blood of rats, compared with other animals and humans, because of firm binding to the hemoglobin in erythrocytes.

Metabolism of inorganic arsenic includes reversible oxidation-reduction so that both arsenite (valence of 3) and arsenate (valence of 5) are present in the urine of animals treated with arsenic of either valence (Ishinishi et al. 1986). Arsenite is subsequently oxidized and methylated by a saturable mechanism to form mono- or dimethylarsenate; the latter is the predominant metabolite in the urine of animals or humans. Organic arsenic compounds (arsenilic acid, cacodylic acid) are not readily converted to inorganic arsenic. Excretion of organic or inorganic arsenic is largely via the urine, but considerable species variation exists. Continuously exposed humans appear to excrete 60 to 70 percent of their daily intake of arsenate or arsenite via the urine.

E.4.3.5.2 Noncancer Toxicity

A lethal dose of arsenic trioxide in humans is 70 to 180 mg (approximately 50 to 140 mg arsenic; Ishinishi et al. 1986). Acute oral exposure of humans to high doses of arsenic produce liver swelling, skin lesions, disturbed heart function, and neurological effects. The only noncancer effects in humans clearly attributable to chronic oral exposure to arsenic are dermal hyperpigmentation and keratosis, as revealed by studies of several hundred Chinese exposed to naturally occurring arsenic in well water (Tseng 1977; Tseng et al. 1968; EPA 1993a). Similar effects were observed in persons exposed to high levels of arsenic in water in Utah and the northern part of Mexico (Cebrian et al. 1983; Southwick et al. 1983). Occupational (predominantly inhalation) exposure is also associated with neurological deficits, anemia, and cardiovascular effects (Ishinishi et al. 1986), but concomitant exposure to other chemicals cannot be ruled out. The EPA (1993a) derived an RfD of 0.3 µg/kg/day for chronic oral exposure, based on an NOAEL of 0.8 µg/kg/day for skin lesions from the Chinese

0561

data. The principal target organ for arsenic appears to be the skin. The nervous system and cardiovascular systems appear to be less significant target organs. Inorganic arsenic may be an essential nutrient, exerting beneficial effects on growth, health, and feed conversion efficiency (Underwood 1977).

E.4.3.5.3 Carcinogenicity

Inorganic arsenic is clearly a carcinogen in humans. Inhalation exposure is associated with increased risk of lung cancer in persons employed as smelter workers, in arsenical pesticide applicators, and in a population residing near a pesticide manufacturing plant (EPA 1993a). Oral exposure to high levels in well water is associated with increased risk of skin cancer (Tseng 1977; EPA 1993a). Extensive animal testing with various forms of arsenic given by many routes of exposure to several species, however, has not demonstrated the carcinogenicity of arsenic (International Agency for Research on Cancer [IARC] 1980). The EPA (1993a) classifies inorganic arsenic in cancer weight-of-evidence Group A (human carcinogen), and recommends an oral unit risk of 0.00005 $\mu\text{g/L}$ in drinking water, based on the incidence of skin cancer in the Tseng (1977) study. The EPA (1993a) notes that the uncertainties associated with the oral unit risk are considerably less than those for most carcinogens, so that the unit risk might be reduced an order of magnitude. An inhalation unit risk of 0.0043 per $\mu\text{g/m}^3$ was derived for inorganic arsenic from the incidence of lung cancer in occupationally exposed men (EPA 1993a).

E.4.3.6 Barium

E.4.3.6.1 Noncancer Toxicity

Barium is a naturally occurring alkaline earth metal that comprises approximately 0.04 percent of the earth's crust (Reeves 1986a). Acute oral toxicity was manifested by GI upset, altered cardiac performance, and transient hypertension, convulsions, and muscular paralysis. Repeated oral exposures were associated with hypertension. Occupational exposure to insoluble barium sulfate induced benign pneumoconiosis (ACGIH 1991). The EPA (1993a) presented a verified chronic oral RfD of 0.07 mg/kg/day, based on an NOAEL of 0.21 mg/kg/day in a ten-week study in humans exposed to barium in drinking water and an uncertainty factor of 3. The EPA (1992b) presented the same value as a provisional RfD for subchronic oral exposure. A provisional chronic inhalation RfC of 0.0005 mg/m^3 and a provisional subchronic inhalation RfC of 0.005 were based on an NOEL for fetotoxicity in a four-month intermittent-exposure inhalation study in rats (EPA 1992b). Uncertainty factors of 1000 and 100 were used for the chronic and subchronic RfC values, respectively. The chronic and subchronic inhalation RfC values are equivalent to 0.0001 and 0.001 mg/kg/day, assuming a human inhalation rate of 20 m^3/day and body weight of 70 kg. Barium is principally a muscle toxin. Its targets are the GI system, skeletal muscle, the cardiovascular system, and the fetus.

E.4.3.6.2 Carcinogenicity

The EPA (1992f) classifies barium as a cancer weight-of-evidence Group D substance (not classifiable as to carcinogenicity in humans). Cancer risk is not estimated for Group D substances.

E.4.3.7 Benzene

E.4.3.7.1 Noncancer Toxicity

In humans, short-term inhalation exposure to benzene induced CNS effects such as drowsiness, dizziness, and headaches; long-term exposure induced anemia (ACGIH 1991). Oral dosing in animals induced hematopoietic effects (Agency for Toxic Substances and Disease Registry [ATSDR] 1989a). Neither oral nor inhalation RfD or RfC values were located for benzene. The CNS and the hematopoietic system are the target organs of benzene.

E.4.3.7.2 Carcinogenicity

The EPA (1993a) classifies benzene in cancer weight-of-evidence Group A (human carcinogen) based on several studies of increased risk of nonlymphocytic leukemia associated with occupational exposure, supported by an increased incidence of neoplasia in rats and mice exposed by inhalation and gavage. A verified oral slope factor of 0.029 per mg/kg/day and inhalation unit risk of $8.3E-06 \mu\text{g}/\text{m}^3$ is based on the increased incidence of leukemia in several occupational (inhalation exposure) studies. The inhalation unit risk is equivalent to 0.029 per mg/kg/day, assuming an inhalation rate of 20 m^3/day and a body weight of 70 kg for humans.

E.4.3.8 Benzoic Acid

E.4.3.8.1 Noncancer Toxicity

There are no reports of toxicity in humans associated with ingestion of 0.9 to 34 mg benzoic acid/day, and the compound is classified as Generally Regarded as Safe (GRAS) by the U.S. Food and Drug Administration (FDA) (EPA 1993a). Effects observed in oral studies in rats and mice were limited to decreased resistance to stress and reduced food and water intake accompanied by decreased growth rate. The EPA (1993a) presented a verified chronic oral RfD of 4 mg/kg/day, based on the upper range of daily intake estimated by the FDA and an uncertainty factor of 1. The EPA (1992b) presented the same value as a provisional subchronic oral RfD. Data are inadequate to identify a target organ for the toxicity of benzoic acid.

E.4.3.8.2 Carcinogenicity

Cancer data consist of a lifetime drinking water study and a five-generation reproduction study in mice that showed no evidence of a carcinogenic effect. The EPA (1993a) classifies benzoic acid as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans). Quantitative risk estimates are not derived for Group D compounds.

E.4.3.9 Beryllium

4787

E.4.3.9.1 Noncancer Toxicity

Beryllium has a low order of toxicity when ingested because it is poorly absorbed from the GI tract (Reeves 1986b). Occupational exposure was associated with dermatitis, acute pneumonitis, and chronic pulmonary granulomatosis (berylliosis). Berylliosis was also observed in humans living in the vicinity of a beryllium plant. Similar pulmonary effects were observed in laboratory animals subjected to inhalation exposure. A verified chronic oral RfD value of 0.005 mg/kg/day was based on an NOAEL in a lifetime drinking water study in rats and an uncertainty factor of 100 (EPA 1993a). The EPA (1992b) presented the same value as a provisional subchronic oral RfD. The target organ for inhalation exposure appears to be the lung; a target organ is not identified for oral exposure.

E.4.3.9.2 Carcinogenicity

The EPA (1993a) classifies beryllium in cancer weight-of-evidence Group B2 (probable human carcinogen) based on inadequate human (occupational) cancer data and sufficient animal data. A significant increase in lung tumors occurred in rats and in rhesus monkeys subjected to inhalation exposure or intratracheal instillation of a variety of beryllium compounds. Osteogenic sarcomas were induced in rabbits and mice, but not in rats or guinea pigs, injected intravenously with various beryllium compounds. Oral studies in animals yielded inconclusive results. The EPA (1993a) derived an oral slope factor of 4.3 per mg/kg/day from a statistically nonsignificant increase in total tumors in a lifetime drinking water study in rats. An inhalation unit risk of 0.0024 per $\mu\text{g}/\text{m}^3$, equivalent to 8.4 per mg/kg/day (assuming an inhalation rate of 20 m^3/day and body weight of 70 kg for humans), was derived from an occupational study.

E.4.3.10 Bis(2-ethylhexyl)phthalate (di[2-ethylhexyl]phthalate)

E.4.3.10.1 Noncancer Toxicity

The acute oral toxicity of bis(2-ethylhexyl)phthalate is very low; oral $\text{LD}_{50/30}$ (lethal dose to 50 percent of population within 30 days without medical treatment) values in rats and mice were 33,800 and 26,300 mg/kg, respectively (ACGIH 1991). Repeated high-dose oral exposures were associated with decreased growth, altered organ weights, testicular degeneration, and developmental effects. The EPA (1993a) presented a verified chronic oral RfD of 0.02 mg/kg/day based on an LOAEL for increased relative liver weight in guinea pigs and an uncertainty factor of 1000. The EPA (1992b) adopted the chronic oral RfD as the provisional subchronic oral RfD. The principal target organs for the toxicity of bis(2-ethylhexyl)phthalate are the liver and testis.

E.4.3.10.2 Carcinogenicity

The EPA (1993a) classifies bis(2-ethylhexyl)phthalate in cancer weight-of-evidence Group B2 (probable human carcinogen), based on inadequate human cancer data (one limited occupational study)

4787

and sufficient cancer data in laboratory animals. An oral slope factor of 0.014 per mg/kg/day was based on the increased incidence of liver tumors in a dietary study in male mice.

E.4.3.11 Boron

E.4.3.11.1 Noncancer Toxicity

Acute exposure to boron compounds was associated with GI irritation and CNS depression (ACGIH 1991). Occupational exposure induced respiratory tract irritation. Several dietary and drinking water studies with boron (chemical form not specified) in dogs, rats, and mice identified testicular atrophy and impaired spermatogenesis as the critical effect of oral exposure (EPA 1993a). Other effects included reduced body and organ weights, reduced ovulation in female rats, and possibly increased extramedullary hematopoiesis in the spleen. The EPA (1993a) presented a verified RfD of 0.09 mg/kg/day for chronic oral exposure to boron, based on an NOAEL in a two-year dietary study in dogs (form of boron not specified). An uncertainty factor of 100 was used. The chronic oral RfD was adopted as the provisional subchronic oral RfD (EPA 1992b). The principal target organs of boron are the testis, respiratory mucosa, and CNS.

E.4.3.11.2 Carcinogenicity

Data were not located regarding the carcinogenicity of boron.

E.4.3.12 Bromodichloromethane

E.4.3.12.1 Noncancer Toxicity

Chronic gavage treatment with bromodichloromethane induced histopathologic evidence of degeneration of the liver and kidney in rats and mice, and hyperplastic lesions of the thyroid in the mice (EPA 1993a). The EPA (1993a) presented a verified chronic oral RfD of 0.02 mg/kg/day based on an NOAEL for kidney effects in mice and an uncertainty factor of 1000. The EPA (1992b) presented the same value as a provisional subchronic oral RfD. The principal target organs of bromodichloromethane are the liver and kidney; the thyroid may be a target in mice.

E.4.3.12.2 Carcinogenicity

The EPA (1993a) classifies bromodichloromethane in cancer weight-of-evidence Group B2 (probable human carcinogen), based on inadequate human data and sufficient animal data. The human data consist of epidemiologic studies that associate chlorination of drinking water with increased risk of several different types of cancer. Bromodichloromethane is one of several trihalogenated methanes formed from the interaction of chlorine with organic matter in water. Animal studies associated treatment with several different tumor types in rats and mice. The EPA (1993a) presented a verified oral slope factor of 0.13 per mg/kg/day, based on the increased incidence of liver tumors in mice treated by gavage. An inhalation risk estimate was not derived.

0565

E.4.3.13 2-Butanone (Methyl Ethyl Ketone)

E.4.3.13.1 Noncancer Toxicity

Toxicity data for oral exposure to 2-butanone were not located. The EPA (1993a) presented a verified RfD for chronic oral exposure of 0.05 mg/kg/day, based on an NOAEL in a 12-week inhalation exposure study in rats and an uncertainty factor of 1000. The provisional subchronic oral RfD is 0.5 mg/kg/day, based on the same study and an uncertainty factor of 100 (EPA 1992b).

Humans exposed to 2-butanone vapor reported slight nose and throat irritation (EPA 1993a). The critical effect of inhalation exposure of animals to 2-butanone appears to be developmental toxicity. The EPA (1993a) presented a verified chronic inhalation RfC of 1 mg/m³, equivalent to 0.3 mg/kg/day for a 70-kg human inhaling 20 m³ of air/day, based on an NOAEL for developmental effects in mice and an uncertainty factor of 3000. The EPA (1992b) presented a provisional subchronic inhalation RfC of 3 mg/m³, based on the 12-week study described in the previous paragraph, but mathematically derived by an obsolete methodology. A more defensible approach would be to adopt the chronic inhalation RfC of 1 mg/m³ as being protective for subchronic exposure as well. The subchronic RfC of 1 mg/m³ is equivalent to 0.3 mg/kg/day, as previously described.

Target organs for 2-butanone are the fetus, respiratory tract, and the CNS.

E.4.3.13.2 Carcinogenicity

EPA (1993a) classifies 2-butanone as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans). Quantitative risk estimates are not derived for Group D compounds.

E.4.3.14 Cadmium

E.4.3.14.1 Pharmacokinetics

Estimates of cadmium uptake by the respiratory tract range from 10 to 50 percent; uptake is greatest for fumes and small particles and least for large dust particles (Friberg et al. 1986; Goyer 1991). GI absorption of ingested cadmium is ordinarily 5 to 8 percent, but may reach 20 percent in cases of serious dietary iron deficiency. Highest tissue levels are normally found in the kidneys followed by the liver, although levels in the liver may exceed those in the kidneys of persons suffering from cadmium-induced renal dysfunction. The half-life of cadmium in the kidneys and liver may be as long as 10-30 years. Fecal and urinary excretion of cadmium are approximately equivalent in normal humans exposed to small amounts. Urinary excretion increases markedly in humans with cadmium-induced renal disease.

E.4.3.14.2 Noncancer Toxicity

Acute inhalation exposure to fumes or particles of cadmium induces respiratory symptoms, general weakness, and, in severe cases, respiratory insufficiency, shock, and death (Friberg et al. 1986). Acute oral exposure induces GI disturbances. Chronic inhalation exposure induces pulmonary emphysema, and chronic exposure by either route consistently produces renal tubular disease in humans and laboratory animals. Proteinuria is a reliable early indicator of cadmium-induced kidney disease. The combination of pulmonary emphysema and renal tubular disease, if severe, may result in early mortality. Painful osteomalacia and osteoporosis may arise from altered metabolism of bone minerals secondary to renal damage. The combination of renal and skeletal damage is called itai-itai disease in Japan. Cadmium exposure has been associated with liver damage, but the liver appears to be less sensitive than the kidney. The kidney is the primary target organ of cadmium toxicity. The EPA (1993a) derived chronic oral RfD values of 0.5 µg/kg/day for cadmium ingested in water and 1 µg/kg/day for cadmium ingested in food, based on a toxicokinetic model that predicted NOAELs from renal cortical concentrations of cadmium. The different RfD values reflect assumed differences in GI absorption of cadmium from water (5 percent) and food (2.5 percent).

E.4.3.14.3 Carcinogenicity

Carcinogenicity data in humans consist of several occupational studies that associate cadmium exposure with lung cancer, but concomitant exposure to other carcinogenic chemicals and smoking were not adequately controlled. Other occupational studies reported significantly increased risk of prostatic cancer, but this effect was not observed in the largest occupational study of workers exposed to high levels (Thun et al. 1985). The animal data consist of an inhalation study in rats that showed a significant increase in lung tumors, and several parenteral injection studies that produced injection site tumors. No evidence of carcinogenicity, however, was observed in seven oral studies in rats and mice. The EPA (1993a) classifies cadmium a cancer weight-of-evidence Group B1 substance for inhalation exposure on the basis of limited evidence of carcinogenicity in humans and sufficient evidence in animals. The data were insufficient to classify cadmium as carcinogenic to humans exposed by the oral route. The EPA (1993a) derived an inhalation unit risk of 0.0018 µg/m³ from the occupational exposure study by Thun et al. (1985).

E.4.3.15 Carbon Tetrachloride

E.4.3.15.1 Noncancer Toxicity

Carbon tetrachloride is a classic hepatotoxicant in humans and animals exposed by any route (ATSDR 1989b). High exposure levels also induced kidney effects in animals. Occupational exposure was associated with CNS and liver effects (ACGIH 1991). The EPA (1993a) presented a verified chronic oral RfD of 0.0007 mg/kg/day based on an NOAEL for liver lesions in a 12-week gavage study in rats and an uncertainty factor of 1000. The EPA (1992b) presented a subchronic oral RfD of 0.007 mg/kg/day, based on the same NOAEL and an uncertainty factor of 100. The principal target organs

for the toxicity of carbon tetrachloride are the liver and the CNS. The kidney is also a target in animals exposed to high levels.

E.4.3.15.2 Carcinogenicity

Carbon tetrachloride is classified in cancer weight-of-evidence Group B2 (probable human carcinogen), based on increased incidence of liver tumors in rats, mice, and hamsters treated orally or by subcutaneous injection (EPA 1993a). A verified oral slope factor of 0.13 per mg/kg/day was based on liver tumor data from gavage studies in all three species previously mentioned. An inhalation unit risk of $1.5E-05$ per $\mu\text{g}/\text{m}^3$, equivalent to 0.053 per mg/kg/day, was derived from the same data and an inhalation absorption factor of 0.4, assuming an inhalation rate of $20 \text{ m}^3/\text{day}$ and a body weight of 70 kg for humans.

E.4.3.16 Chlorobenzene

E.4.3.16.1 Noncancer Toxicity

Oral exposure of animals to chlorobenzene induced liver effects (EPA 1993a). Inhalation exposure of animals induced narcosis and other CNS effects as well as lung, liver, and kidney changes (ACGIH 1991). Minimal occupational exposure data indicated that chlorobenzene induces respiratory tract irritation and CNS effects (headache) in workers exposed to high levels. The EPA (1993a) presented a verified chronic oral RfD of 0.02 mg/kg/day, based on an NOAEL for liver lesions in a 13-week oral study in dogs and an uncertainty factor of 1000. The EPA (1992b) presented a provisional subchronic oral RfD of 0.2 mg/kg/day, based on the same NOAEL and an uncertainty factor of 100. A provisional chronic inhalation RfC of $0.02 \text{ mg}/\text{m}^3$ is based on an LOAEL for liver and kidney effects in rats exposed by inhalation for 120 days and an uncertainty factor of 10,000 (EPA 1992b). The provisional subchronic inhalation RfC, based on the same LOAEL and an uncertainty factor of 1000, is $0.2 \text{ mg}/\text{m}^3$. The chronic and subchronic inhalation RfC values are equivalent to 0.006 and 0.06 mg/kg/day, respectively, assuming an inhalation rate of $20 \text{ m}^3/\text{day}$ and a body weight of 70 kg for humans. Target organs for the toxicity of chlorobenzene include the liver, CNS, lung, and kidney.

E.4.3.16.2 Carcinogenicity

Chlorobenzene is classified as an EPA cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity for humans), based on no available human cancer data and inadequate animal data (EPA 1993a). Quantitative risk estimates are not derived for Group D compounds.

E.4.3.17 Chloroform

E.4.3.17.1 Noncancer Toxicity

Oral or inhalation exposure of animals to chloroform was associated with liver and kidney damage (ACGIH 1991; EPA 1993a). In humans, acute inhalation exposure to high levels induced narcosis,

4787

ventricular fibrillation, and death (ACGIH 1991). Limited occupational data associated chronic exposure to chloroform with CNS depression, digestive disturbances, and enlarged livers. The EPA (1993a) presented a verified chronic oral RfD of 0.01 mg/kg/day based on an LOAEL for fatty cyst formation in the livers of dogs treated orally for 7.5 years and an uncertainty factor of 1000. The same value was presented as a provisional subchronic oral RfD (EPA 1992b). Target organs for the toxicity of chloroform include the liver and kidney for oral and inhalation exposure, and the heart and CNS for inhalation exposure.

E.4.3.17.2 Carcinogenicity

Chloroform is classified as a cancer weight-of-evidence Group B2 compound (probable human carcinogen), based on increased incidence of several tumor types in rats and liver tumors in mice (EPA 1993a). Human carcinogenicity data are inadequate. An oral slope factor of 0.0061 per mg/kg/day was derived from the incidence of kidney tumors in rats treated with chloroform in drinking water for two years. An inhalation unit risk of $2.3E-05$ per $\mu\text{g}/\text{m}^3$ was based on the incidence of hepatocellular carcinomas in mice treated by gavage for 78 weeks. The inhalation unit risk is equivalent to 0.081 per mg/kg/day, assuming an inhalation rate of $20 \text{ m}^3/\text{day}$ and a body weight of 70 kg for humans.

E.4.3.18 4-Chloro-3-methylphenol (p-chloro-m-cresol)

E.4.3.18.1 Noncancer Toxicity

Toxicologic data for 4-chloro-3-methylphenol were very limited. The oral lethal dose to 50 percent of the population ($\text{LD}_{50/30}$) in rats was determined to be 500 mg/kg (Sax 1984).

E.4.3.18.2 Carcinogenicity

Data were not located regarding the carcinogenicity of 4-chloro-3-methylphenol.

E.4.3.19 2-Chlorophenol

E.4.3.19.1 Noncancer Toxicity

Little information was located regarding the noncancer toxicity of 2-chlorophenol. Oral $\text{LD}_{50/30}$ values ranged from 440 to 670 mg/kg (Sax 1984). The EPA (1993a) presented a verified chronic oral RfD of 0.005 mg/kg/day based on an NOAEL for reproductive effects in a subchronic drinking water study in rats and an uncertainty factor of 1000. The EPA (1992b) presented a provisional subchronic oral RfD of 0.05 mg/kg/day based on the same NOAEL and an uncertainty factor of 100. The fetus appears to be a target organ for the oral toxicity of 2-chlorophenol.

E.4.3.19.2 Carcinogenicity

Data were not located regarding the carcinogenicity of 2-chlorophenol.

E.4.3.20 4-Chlorophenyl Phenyl Ether (4-Chlorodiphenyl Ether)

E.4.3.20.1 Noncancer Toxicity

The toxicity of the chlorinated phenyl ethers increases with the extent of chlorination (Kirwin and Sandmeyer 1981). The mono-, di-, and tri-chlorophenyl ethers do not present a serious hazard in the industrial setting. The most noteworthy effect of exposure to the more highly chlorinated phenyl ethers is acneform dermatitis, suggestive of the chloracne induced by dibenzo-p-dioxins, PCBs, and polychlorinated dibenzofurans (PCDFs), all of which are structurally similar to the chlorinated phenyl ethers.

For monochlorophenyl phenyl ether (position of the chlorine not specified), the smallest single oral dose that caused mortality in guinea pigs within 30 days of treatment was 600 mg/kg (Kirwin and Sandmeyer 1981). In repeated dose gavage studies in rabbits (5 days/week for 4 weeks), 100 mg/kg was without effect.

E.4.3.20.2 Carcinogenicity

Data were not located regarding the carcinogenicity of 4-chlorophenyl phenyl ether. 4-Bromophenyl phenyl ether, which is structurally very similar to 4-chlorophenyl phenyl ether, was negative in the Strain A mouse pulmonary tumor assay following intraperitoneal treatment (Theiss et al. 1977).

E.4.3.21 3-Chloropropene (Allyl Chloride)

E.4.3.21.1 Noncancer Toxicity

The compound 3-chloropropene is more commonly known by its synonym, allyl chloride (EPA 1993a). The compound was shown to induce peripheral neuropathy, manifested as motor and sensory deficits, in occupationally exposed humans (He et al. 1980, 1985). Exposure concentrations were not sufficiently quantified to locate thresholds for these effects. An earlier study associated occupational exposure with liver damage (Hausler and Lenich 1968), but the study was flawed and could not be properly evaluated. It does not appear that neurological endpoints were examined in this study.

Clinical, electromyographic, and histopathologic evidence of peripheral neuropathy were observed in rabbits and a cat intermittently exposed to 3-chloropropene in air for ≥ 3 months (Boquin et al. 1982). Rats, guinea pigs, and rabbits exposed via inhalation also developed degenerative lesions in the kidneys (Quast et al. 1982; Torkelson et al. 1959). Rabbits and mice treated by subcutaneous and oral dosing, respectively, also showed neurologic and kidney effects. It is unclear whether exposure to 3-chloropropene induces liver effects in animals.

The EPA (1993a) derived an RfC of 0.001 mg/m^3 for chronic inhalation exposure to 3-chloropropene, based on an NOAEL of approximately 5 ppm (17 mg/m^3) for peripheral neuropathy in rabbits (Boquin

0570

et al. 1982). An uncertainty factor of 3000 was applied; factors of 10 each for expansion from subchronic to chronic exposure, for protection for sensitive human subpopulations, and for deficiencies in the database (including lack of adequate developmental and reproductive toxicity data, and a factor of 3 to reflect the uncertainty in the animal-to-human dosimetric extrapolation.

E.4.3.21.2 Carcinogenicity

Cancer data include an increased incidence of squamous cell papillomas and carcinomas in mice in an inadequate gavage study in rats and mice (National Cancer Institute [NCI] 1978b), an increase in lung tumor multiplicity in strain A/St mice treated by intraperitoneal injection (Theiss et al. 1979), and tumor initiation in the two-stage skin-painting test in mice (Van Duuren et al. 1979). On the basis of these data, EPA (1993a) classifies 3-chloropropene as a cancer weight-of-evidence Group C compound (possible human carcinogen). The data were inadequate for quantitative estimation of carcinogenic potency.

E.4.3.22 Chromium

E.4.3.22.1 Noncancer Toxicity

In nature, chromium (III) predominates over chromium (VI) (Langård and Norseth 1986). Little chromium (VI) exists in biological materials, except shortly after exposure, because reduction to chromium (III) occurs rapidly. Chromium (III) is considered a nutritionally essential trace element and is considerably less toxic than chromium (IV). No effects were observed in rats consuming 1800 mg chromium (III)/kg/day in the diet for over two years (EPA 1993a). The NOEL of 1800 mg/kg/day and an uncertainty factor of 1000 was the basis for a verified chronic oral RfD of 1 mg/kg/day (EPA 1993a). The same NOEL and an uncertainty factor of 100 was the basis for a provisional subchronic oral RfD of 10 mg/kg/day (EPA 1993a).

Acute oral exposure of humans to high doses of chromium (VI) induced neurological effects, GI hemorrhage and fluid loss, and kidney and liver effects. Parenteral dosing of animals with chromium (VI) is selectively toxic to the kidney tubules. An NOAEL of 2.4 mg chromium (VI)/kg/day in a one-year drinking water study in rats and an uncertainty factor of 500 was the basis of a verified RfD of 0.005 mg/kg/day for chronic oral exposure (EPA 1993a). The same NOAEL and an uncertainty factor of 100 was the basis of a provisional subchronic oral RfD of 0.02 mg/kg/day (EPA 1993a).

Occupational (inhalation and dermal) exposure to chromium (III) compounds induced dermatitis (ACGIH 1991). Similar exposure to chromium (VI) induced ulcerative and allergic contact dermatitis, irritation of the upper respiratory tract including ulceration of the mucosa and perforation of the nasal septum, and possibly kidney effects. Inhalation RfC values were not located.

0571

A target organ was not identified for chromium (III). The kidney appears to be the principal target organ for repeated oral dosing with chromium (VI). Additional target organs for dermal and inhalation exposure include the skin and respiratory tract.

E.4.3.22.2 Carcinogenicity

Data were not located regarding the carcinogenicity of chromium (III). The EPA (1993a) classifies chromium (VI) in cancer weight-of-evidence Group A (human carcinogen), based on the consistent observation of increased risk of lung cancer in occupational studies of workers in chromate production or the chrome pigment industry. Parenteral dosing of animals with chromium (VI) compounds consistently induced injection-site tumors. There is no evidence that oral exposure to chromium (VI) induces cancer. An inhalation unit risk of 0.012 per $\mu\text{g}/\text{m}^3$, equivalent to 41 per $\text{mg}/\text{kg}/\text{day}$, assuming humans inhale 20 m^3/day and weigh 70 kg, was based on increased risk of lung cancer deaths in chromate production workers.

E.4.3.23 Chlordane

Technical chlordane is a mixture of at least 50 related compounds (ATSDR 1989c). The principal components of the mixture are cis- and trans-chlordane, heptachlor, cis- and trans-nonachlor, and alpha-, beta- and gamma-chlordene. Each component has its own environmental fate and transport kinetics, so it is unlikely that the chlordane identified at the site would have the same chemical composition as technical chlordane. It is unclear which chlordane component(s) were found at the site.

E.4.3.23.1 Pharmacokinetics

Kinetic studies in rats, in which the area under the curve was compared following intravenous and oral dosing, indicate that approximately 80 percent of an oral dose of trans-chlordane is absorbed from the GI tract (Ohno et al. 1986). In animals, absorbed chlordane is distributed most rapidly to the liver and kidneys, probably because of the extensive vascularity of these organs (Ohno et al. 1986), followed by redistribution to adipose tissue (Barnett and Dorough 1974). In humans, levels of chlordane residues in adipose tissue increase with increasing duration of exposure (ATSDR 1989c). Metabolism involves principally oxidation, dechlorination, and conjugation, yielding lipophilic products that accumulate in adipose tissue as well as more polar products that are excreted. Chlordane residues are excreted principally through the bile, although considerable species differences occur. Lactation is an important mechanism of excretion of chlordane residues retained in body fat.

E.4.3.23.2 Noncancer Toxicity

An acute oral lethal dose of chlordane in humans is estimated to be 25 to 50 mg/kg (ATSDR 1989c). Symptoms of acute oral or inhalation intoxication in humans consistently include GI disturbances such as vomiting, cramps, and diarrhea, and neurological effects including headache, irritability, dizziness, incoordination, convulsions, and coma. Data were not located regarding symptoms or effects in humans chronically exposed by the oral route, and no noncancer effects were observed in several

4787

studies of occupationally exposed humans. Mild liver lesions were observed in chronic oral studies in rats and mice. Prenatal or early postnatal exposure of mice to chlordane damages the developing immune system and nervous system. Target organs of chlordane include the liver, nervous system, and the fetus and neonate.

The EPA (1993a) derived an RfD of 0.06 $\mu\text{g/kg/day}$ for chronic oral exposure to chlordane, based on an NOEL of 0.055 mg/kg/day for liver effects in a 30-month dietary study in rats (Velsicol Chemical Co., 1983). An uncertainty factor of 1000 was applied; factors of 10 each for inter- and intraspecies variation, and to reflect deficiencies in the database.

E.4.3.23.3 Carcinogenicity

The EPA (1993a) classifies chlordane in cancer weight-of-evidence Group B2, based on inadequate evidence in humans and sufficient evidence in animals. The human data consist of several epidemiologic studies of chlordane manufacturing workers and pesticide applicators. The only indication of a carcinogenic effect was a borderline significantly increased incidence of bladder cancer in one study of pesticide applicators, but chlordane exposure was not quantified and the workers were concomitantly exposed to other carcinogenic pesticides. The animal data consist of several studies in which oral exposure induced a dose-related increase in the incidence of liver tumors. The evidence for carcinogenicity in rats is equivocal. The EPA (1993a) derived an oral slope factor of 1.3 per mg/kg/day and an inhalation unit risk of 0.00037 per $\mu\text{g/m}^3$ based on liver tumor incidence in two dietary studies in mice.

E.4.3.24 Cobalt

E.4.3.24.1 Noncancer Toxicity

Acute high oral or parenteral doses of cobalt in humans or animals induced myocardial degeneration often leading to mortality, erythropoiesis, enlarged thyroid, and, in animals, renal tubular degeneration (Elinder and Friberg 1986b). Chronic ingestion from the consumption of beer containing high concentrations of cobalt was associated with "beer-drinkers cardiomyopathy," which includes polycythemia and goiter, as well as marked myocardial degeneration and mortality. The therapeutic use of 0.16 to 0.32 mg cobalt/kg/day in anemic, anephric dialysis patients for 12 to 32 weeks induced a significant, but reversible, rise in blood hemoglobin concentration (EPA 1992g).

Occupational (inhalation and dermal) exposure was associated with allergic dermatitis, chronic interstitial pneumonitis, reversibly impaired lung function, occupational asthma, and myocardial effects (ACGIH 1991). Cobalt was determined to be the etiologic factor in hard metal disease, the syndrome of respiratory symptoms, and pneumoconiosis associated with inhalation exposure to dusts containing tungsten carbide with cobalt powder as a binder (Elinder and Friberg 1986b). The lowest occupational air concentration of cobalt associated with hard metal disease was 0.003 mg cobalt/ m^3 (Sprince et al.

1988). It should be noted that the workers were also exposed to tungsten and sometimes to titanium, tantalum, and niobium (Elinder and Friberg 1986b). Similar lung effects were seen in animals exposed to cobalt by inhalation.

The developmental toxicity of cobalt was tested in rodents treated orally with cobalt chloride (EPA 1992g). Maternal effects (unspecified) were reported in rats treated with 5.4 to 21.8 mg cobalt/kg/day from gestation day 14 through lactation day 21. Effects on the offspring included stunted growth at 5.4 mg cobalt/kg/day and reduced survival at 21.8 mg cobalt/kg/day. In rats treated with 6.2, 12.4, or 24.8 mg cobalt/kg/day on gestation days 6 through 15, maternal effects included reduced food consumption and body weight gain and altered hematologic parameters, although it is unclear at what dose level(s) these effects occurred. There were no effects on fetal survival, although a nonsignificant increase in fetal stunting was observed in rats treated with ≥ 12.4 mg cobalt/kg/day. Mice treated with 81.7 mg cobalt/kg/day had reduced maternal weight gain, but no fetal effects.

Several studies reported testicular degeneration and atrophy in rats treated with cobalt chloride in the diet or drinking water at concentrations equivalent to doses of 5.7 to 30.2 mg cobalt/kg/day (EPA 1992g).

Cobalt is nutritionally essential as a cofactor in cyanocobalamin (vitamin B12) (EPA 1992g). Cobalt is universally present in the diet. Average daily adult dietary intakes of cobalt range from 0.16 to 0.58 mg/day (0.002 to 0.008 mg/kg/day, assuming adults weigh 70 kg) (Tipton et al. 1966; Schroeder et al. 1967). In 9- to 12-year-old children, dietary intakes of cobalt range from 0.3 to 1.77 mg/day (Murthy et al. 1971; National Research Council 1989). Assuming an average weight for children in this age range of 28 kg (National Research Council, 1989), the dietary intakes are equivalent to 0.01 to 0.06 mg/kg/day.

The EPA (1992g) concluded that the oral toxicity data were insufficient for derivation of an oral RfD for cobalt. The relatively well characterized dietary intake data, however, can provide useful guidance. The EPA (1992g) noted that the upper range of dietary intake for children, 0.06 mg/kg/day, was below the level associated with enhanced erythropoiesis in anephric patients. Therefore, the upper range of dietary intake, 0.06 mg cobalt/kg/day, can be considered a guidance level for the oral intake of cobalt and can be used in place of an oral RfD in CERCLA and RCRA baseline risk assessments.

The EPA (1990b) derived an interim inhalation RfC from the LOAEL of 0.003 mg cobalt/m³ associated with hard metal disease in occupationally exposed humans (Sprince et al. 1988). Correcting for intermittent occupational exposure (10 m³ of air inhaled per work day/20 m³ of air inhaled per day x 5 work days per week/7 days per week) yielded an adjusted LOAEL of 0.001 mg/m³. Application of an uncertainty factor of 1000 resulted in an interim chronic inhalation RfC of 1E-06 mg/m³.

Assuming humans inhale 20 m^3 of air/day and weigh 70 kg, the RfC is equivalent to $2.9\text{E-}07$ mg/kg/day, rounded to $3\text{E-}07$ mg/kg/day.

Important target organs in orally exposed humans are the heart, erythrocyte, and thyroid. Target organs for occupational exposure are the skin, lungs, and heart.

E.4.3.24.2 Carcinogenicity

Data regarding the carcinogenicity of cobalt were not located.

E.4.3.25 Copper

E.4.3.25.1 Noncancer Toxicity

Copper is a nutritionally essential element that functions as a cofactor in several enzyme systems (Aaseth and Norseth 1986). Acute exposure to large oral doses of copper salts was associated with GI disturbances, hemolysis, and liver and kidney lesions. Chronic oral toxicity in humans has not been reported. Chronic oral exposure of animals was associated with an iron-deficiency type of anemia, hemolysis, and lesions in the liver and kidneys. Occupational exposure may induce metal fume fever, and, in cases of chronic exposure to high levels, hemolysis and anemia (ACGIH 1991). Neither oral nor inhalation RfD or RfC values were located for copper. The target organs for copper are the erythrocyte, liver, and kidney, and, for inhalation exposure, the lung.

E.4.3.25.2 Carcinogenicity

Copper is classified in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans) (EPA 1993a). Quantitative risk estimates are not derived for Group D chemicals.

E.4.3.26 Cyanide

E.4.3.26.1 Noncancer Toxicity

Acute exposure to cyanide induced histotoxic hypoxia (inability of the tissues to use oxygen); death was due to central respiratory arrest (Smith 1991). Chronic dietary exposure to cyanide was associated with reduced body weight gain, decreased thyroid activity, myelin degeneration, and reduced fertility in rats (EPA 1993a). The EPA (1993a) presented a verified RfD of 0.02 mg/kg/day for oral exposure to cyanide, based on an NOAEL in a two-year study in rats that consumed food fumigated with hydrogen cyanide, and an uncertainty factor of 500. The same value was adopted as the provisional RfD for subchronic oral exposure (EPA 1992b). The target organs for acute exposure are the CNS, respiratory system, and cardiovascular system (ACGIH 1991). Target organs for chronic oral exposure to cyanide appear to be the thyroid and nervous system.

E.4.3.26.2 Carcinogenicity

The EPA (1993a) classifies cyanide as a cancer weight-of-evidence Group D substance (not classifiable as to carcinogenicity to humans). Quantitative risk estimates are not derived for Group D chemicals.

E.4.3.27 4,4-Dichlorodiphenyltrichloroethane (DDT)**E.4.3.27.1 Noncancer Toxicity**

The CNS is an important target organ in humans acutely exposed to DDT. Symptoms include altered sensory perception, headache, nausea, disequilibrium, confusion, tremors, and convulsions (Hayes 1982; ATSDR 1989d). Tremors and hyperirritability were observed in chronically exposed animals (NCI 1978c; Rossi et al. 1977). The liver appears to be the other important target organ, at least in animals. Liver effects include enzyme induction, increased liver weight, increased serum levels of liver enzymes, hepatocellular hypertrophy, and necrosis (ATSDR 1989d). The EPA (1993a) derived an RfD of 0.5 µg/kg/day for chronic oral exposure from an NOEL of 0.05 mg/kg/day for liver effects in a 15- to 27-week feeding study in rats (Laug et al. 1950). An uncertainty factor of 100 was applied with factors of 10 each for inter- and intraspecies variation.

E.4.3.27.2 Carcinogenicity

The DDT is classified by EPA (1993a) as a cancer weight-of-evidence Group B2 compound (probable human carcinogen), on the basis of inadequate human data and sufficient animal data. The human data consist of occupational studies of insufficient duration to identify a carcinogenic effect, and conflicting studies regarding tissue concentrations of DDT residues in cancer victims compared with controls (EPA 1993a). The EPA (1993a) derived an oral slope factor of 0.34 per mg/kg/day and an inhalation unit risk of 0.000097 per µg/m³ from the incidence of benign and malignant liver tumors in several oral studies in mice and rats.

E.4.3.28 Dibenzofuran**E.4.3.28.1 Noncancer Toxicity**

Although data associated the PCDFs with chloracne and other effects in humans (ATSDR 1992), data were not located regarding the oral or inhalation toxicity of unsubstituted dibenzofuran. Neither oral nor inhalation RfD or RfC values for dibenzofuran were located. Target organs for dibenzofuran have not been identified.

E.4.3.28.2 Carcinogenicity

Although data associated the PCDFs with cancer in humans (ATSDR 1992), data were not located regarding the carcinogenicity of unsubstituted dibenzofuran. The EPA (1993a) classifies dibenzofuran

a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans) because of the lack of data. Cancer risks are not estimated for Group D compounds.

E.4.3.29 Dibenzo-p-dioxins/Dibenzofurans

Specific congeners and homologues of these classes of interest at this site include 1,2,3,4,6,7,8-heptachlorodibenzofuran and -heptachlorodibenzo-p-dioxin; 1,2,3,4,7,8,9-heptachlorodibenzofuran and -heptachlorodibenzo-p-dioxin; 1,2,3,4,7,8-hexachlorodibenzofuran and -hexachlorodibenzo-p-dioxin; 1,2,3,6,7,8- and 2,3,4,6,7,8-hexachlorodibenzofuran; 1,2,3,7,8,9-hexachlorodibenzofuran and -hexachlorodibenzo-p-dioxin; 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin; unspecified hexachlorodibenzofurans and dibenzo-p-dioxins; 1,2,3,7,8- and 2,3,4,7,8-pentachlorodibenzofuran; unspecified pentachlorodibenzofurans; 2,3,7,8-tetrachlorodibenzofuran; and unspecified tetrachlorodibenzofurans.

E.4.3.29.1 Noncancer Toxicity

Of the members of these classes, the toxicity of 2,3,7,8-TCDD has been studied most extensively. The only effect in humans clearly attributable to 2,3,7,8-TCDD was chloracne (ATSDR 1989e). The data, however, also associated exposure to 2,3,7,8-TCDD with hepatotoxicity and neurotoxicity in humans. In animals, toxicity of 2,3,7,8-TCDD is most commonly manifested as a wasting syndrome with thymic atrophy, terminating in death, with a large number of organ systems showing nonspecific effects. Chronic treatment of animals with 2,3,7,8-TCDD or a mixture of two isomers of hexachlorodibenzo-p-dioxin resulted in liver damage. Immunologic effects may be among the more sensitive endpoints of exposure to the PCDDs in animals. In animals 2,3,7,8-TCDD is a developmental and reproductive toxicant. No verified or provisional noncancer toxicity values were located for any of the chemicals of interest in these classes (EPA 1993a, 1992b).

E.4.3.29.2 Carcinogenicity

Data regarding the carcinogenicity of 2,3,7,8-TCDD to humans, obtained from epidemiologic studies of workers exposed to pesticides or to other chlorinated chemicals known to be contaminated with 2,3,7,8-TCDD, are conflicting (ATSDR 1989e). The interpretation of these studies is not clear because exposure to 2,3,7,8-TCDD was not quantified, multiple routes of exposure (dermal, inhalation, oral) were involved, and the workers were exposed to other potentially carcinogenic compounds. In animals, however, 2,3,7,8-TCDD is clearly carcinogenic, inducing thyroid, lung, and liver tumors in orally treated rats and mice (EPA 1985). Similarly, oral treatment with a mixture of two hexachlorodibenzo-p-dioxin isomers induced liver tumors in rats and mice. On the basis of the animal data, 2,3,7,8-TCDD and the hexachlorodibenzo-p-dioxins were assigned to EPA cancer weight-of-evidence Group B2 (probable human carcinogen). Although the other PCDDs and PCDFs were not formally classified as to carcinogenicity to humans, for regulatory purposes they are treated as probable human carcinogens.

The EPA (1992b) presents provisional oral and inhalation slope factors for 2,3,7,8-TCDD of 150,000 per mg/kg/day, based on the incidence of liver and lung tumors in an oral study in rats (Kociba et al. 1978).

Much less is known about the toxicity of other CDD and CDF congeners. Based on available toxicity data, EPA has developed a method for expressing toxicities of these compounds in terms of equivalent amounts of 2,3,7,8-TCDD. "Toxicity equivalency factors", or TEFs, are used to convert the concentration of a given CDD/CDF into an equivalent concentration of 2,3,7,8-TCDD. The TEF approach has been applied in the risk assessment of dioxins and furans for Operable Unit 1. Table D.4-3 presents the TEFs developed by EPA (1990d).

E.4.3.30 Di-n-butylphthalate (dibutylphthalate)

E.4.3.30.1 Noncancer Toxicity

The oral and inhalation toxicities of di-n-butylphthalate appear to be quite low (ACGIH 1991). Oral doses of 2000 mg/kg/day for 10 days induced testicular degeneration in mice and guinea pigs, but not in rats or hamsters. A one-year dietary study with di-n-butylphthalate resulted in mortality of half the rats within the first week; no adverse effects were observed in the survivors (EPA 1993a). A verified chronic oral RfD of 0.1 mg/kg/day was derived from the NOAEL in the one-year rat study and an uncertainty factor of 1000. The same NOAEL and an uncertainty factor of 100 were the basis of a provisional subchronic oral RfD of 1 mg/kg/day (EPA 1992b). The testis appears to be a target organ for oral exposure in some species.

E.4.3.30.2 Carcinogenicity

The EPA (1993a) classifies di-n-butylphthalate in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans), based on an absence of human or animal cancer data. Quantitative risk estimates are not derived for Group D chemicals.

E.4.3.31 3,3'-Dichlorobenzidine

E.4.3.31.1 Noncancer Toxicity

The oral toxicity of 3,3'-dichlorobenzidine appears to be low. The oral LD_{50/30} in rats is 7000 mg/kg, and 9 of 14 rats survived gavage treatment with 700 mg/kg for >288 days (ACGIH 1991). The EPA (1993a) reviewed the available inhalation data and concluded that the data were insufficient for derivation of an RfC for chronic inhalation exposure.

E.4.3.31.2 Carcinogenicity

Epidemiology studies failed to implicate 3,3'-dichlorobenzidine as a human carcinogen (Gadian 1975; Gerarde and Gerarde 1974; MacIntyre 1975), but several flaws in these studies seriously compromised

their sensitivity (EPA 1993a). 3,3'-Dichlorobenzidine was associated with tumors in several sites in rats, in the liver and urinary bladder in dogs, in the liver in mice, and in the urinary bladder in hamsters (Osanai 1976; Safiotti et al. 1967; Stula et al. 1975, 1978). The EPA (1993a) classified 3,3'-dichlorobenzidine as a cancer weight-of-evidence Group B2 compound, and derived a slope factor for oral exposure of 0.45 per mg/kg/day, based on the incidence of mammary adenocarcinomas in female rats (Stula et al. 1975).

E.4.3.32 Dichlorodifluoromethane

E.4.3.32.1 Noncancer Toxicity

Oral exposure to dichlorodifluoromethane induces a low order of toxicity. In a two-year study, 150 mg/kg/day decreased the rate of body weight gain in female rats; no effects were observed in rats receiving 15 mg/kg/day (Sherman 1974). The method of oral dosing (diet or gavage) was unclear. No clinical signs, organ weight effects, or histopathologic alterations were observed in rats treated with 430 mg/kg/day for 10 days or in dogs treated with 90 mg/kg/day for 90 days (Clayton 1967). The EPA (1993a) derived an RfD of 0.2 mg/kg/day for chronic oral exposure from the NOEL of 15 mg/kg/day in the two-year rat study. An uncertainty factor of 100 was applied with factors of 10 each for inter- and intraspecies variation.

E.4.3.32.2 Carcinogenicity

Data were not located in EPA (1993a) regarding the carcinogenicity of dichlorodifluoromethane.

E.4.3.33 1,1-Dichloroethane

E.4.3.33.1 Noncancer Toxicity

CNS depression was the critical effect of oral or inhalation exposure of animals to 1,1-dichloroethane (ACGIH 1991). Kidney damage was observed in cats, but not laboratory rodents, exposed by inhalation. Inhalation exposure of humans was associated with CNS depression and respiratory tract and ocular irritation. The EPA (1992b) presented a provisional chronic oral RfD of 0.1 mg/kg/day based on an NOEL in a 13-week intermittent exposure inhalation study in rats and an uncertainty factor of 1000. A provisional subchronic oral RfD of 1 mg/kg/day was based on the same NOEL and an uncertainty factor of 100. The EPA (1992b) presented a provisional chronic inhalation RfC of 0.5 mg/m³ based on an NOEL for kidney damage in cats exposed by inhalation to 1,1-dichloroethane and an uncertainty factor of 1000. A provisional subchronic inhalation RfC of 5 mg/m³ was based on the same NOEL and an uncertainty factor of 100. The chronic and subchronic inhalation RfC values are equivalent to 0.1 and 1 mg/kg/day, respectively, assuming an inhalation rate of 20 m³/day and a body weight of 70 kg for humans. Target organs for the toxicity of 1,1-dichloroethane are the CNS and kidney (in the cat) for oral exposure, and the CNS and respiratory and ocular mucosa for inhalation exposure.

E.4.3.33.2 Carcinogenicity

EPA classifies 1,1-dichloroethane as a cancer weight-of-evidence Group C compound (possible human carcinogen), based on no human cancer data and limited evidence of carcinogenicity in animals (EPA 1993a). The data were considered to be inadequate for quantitative cancer baseline risk assessment.

E.4.3.34 1,2-Dichloroethane**E.4.3.34.1 Noncancer Toxicity**

Oral or inhalation exposure of humans or laboratory animals to 1,2-dichloroethane induced liver and kidney effects (ACGIH 1991). Inhalation exposure also induced pulmonary congestion or edema, and, in humans, CNS depression. Neither oral nor inhalation RfD or RfC values were located. The target organs for 1,2-dichloroethane toxicity are the liver, kidney, lung, and CNS.

E.4.3.34.2 Carcinogenicity

EPA classifies 1,2-dichloroethane as a cancer weight-of-evidence Group B2 compound (probable human carcinogen), based on the induction of several tumor types in rats and mice treated by gavage, and on the induction of benign lung papillomas in mice after dermal application (EPA 1993a). The EPA (1993a) presented a slope factor for oral exposure of 0.091 per mg/kg/day, and a unit risk for inhalation exposure of $2.6E-05$ per $\mu\text{g}/\text{m}^3$, based on the incidence of vascular system hemangiosarcomas in male rats in the gavage study. The inhalation unit risk is equivalent to 0.091 per mg/kg/day, assuming humans inhale 20 m^3 of air/day and weigh 70 kg.

E.4.3.35 1,1-Dichloroethene**E.4.3.35.1 Noncancer Toxicity**

Chronic oral exposure of laboratory animals to 1,1-dichloroethene induced liver effects (EPA 1993a). In animals, inhalation exposure induced degenerative changes in the liver and kidneys (ATSDR 1989f). No health effects were observed in a limited study of 138 exposed workers (ACGIH 1986). The EPA (1993a) presented a verified RfD for chronic oral exposure of 0.009 mg/kg/day, based on an NOAEL for liver effects in a chronic drinking water study in rats and an uncertainty factor of 1000. The EPA (1992b) presented the same value as a provisional subchronic oral RfD. The liver and kidneys are the target organs for exposure to 1,1-dichloroethene.

E.4.3.35.2 Carcinogenicity

EPA classifies 1,1-dichloroethene as a cancer weight-of-evidence Group C compound (possible human carcinogen), based on an inadequate occupational exposure cancer study, limited data in several animal studies, its mutagenicity and ability to alkylate deoxyribonucleic acid (DNA), and its structural similarity to vinyl chloride, a known human carcinogen (EPA 1993a). The eighteen available animal studies (11 by inhalation exposure, 5 by oral exposure, and 1 each by dermal application and

subcutaneous injection) were limited in sensitivity by various deficiencies in design. Credible evidence that 1,1-dichloroethene was a complete carcinogen was provided only by one 12-month inhalation study in mice, in which the incidence of kidney adenocarcinomas was significantly greater in the high-dose males than in the control males. A slope factor of 0.6 per mg/kg/day for oral exposure was based on the increased incidence of adrenal pheochromocytomas in male rats treated by gavage for two years, even though the increase was not statistically significant. A unit risk for inhalation exposure of $5.0\text{E-}05$ per $\mu\text{g}/\text{m}^3$ was based on the incidence of kidney adenocarcinomas in male mice in the inhalation study mentioned above. The unit risk is equivalent to 0.175 per mg/kg/day, assuming humans inhale 20 m^3 of air/day and weigh 70 kg.

E.4.3.36 cis-1,2-Dichloroethene (c-1,2-Dichloroethylene)

E.4.3.36.1 Noncancer Toxicity

Repeated oral exposure of rats to cis-1,2-dichloroethene was associated with signs of anemia (decreased hematocrit and hemoglobin) (EPA 1992b). Inhalation exposure to isomeric mixtures of 1,2-dichloroethene induced narcosis, and mixed isomers of 1,2-dichloroethene were used as an anesthetic gas (ACGIH 1991). The EPA (1992b) presented a provisional chronic oral RfD of 0.01 mg/kg/day based on an NOAEL for signs of anemia in rats and an uncertainty factor of 3000. A provisional subchronic oral RfD of 0.1 mg/kg/day was derived from the same NOAEL and an uncertainty factor of 300. Target organs appear to be the erythrocyte for oral exposure and the CNS for inhalation exposure.

E.4.3.36.2 Carcinogenicity

The EPA (1993a) classifies cis-1,2-dichloroethene as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans), based on an absence of human or animal cancer data. Quantitative estimates of cancer risk are not derived for Group D chemicals.

E.4.3.37 trans-1,2-Dichloroethene (t-1,2-Dichloroethylene)

E.4.3.37.1 Noncancer Toxicity

The oral $\text{LD}_{50/30}$ for trans-1,2-dichloroethene in rats was 1275 mg/kg; death was preceded by CNS and respiratory depression (ACGIH 1991). Histopathologic examination revealed lesions in the lungs and heart. Prolonged oral administration induced clinicopathologic evidence of mild liver damage (EPA 1993a). An NOAEL for this effect in a 90-day drinking water study in mice and an uncertainty factor of 1000 was the basis for a verified chronic oral RfD of 0.02 mg/kg/day. A provisional subchronic oral RfD of 0.2 mg/kg/day was derived from the same NOAEL and an uncertainty factor of 100 (EPA 1992b). The target organs for inhalation exposure to trans-1,2-dichloroethene are the CNS, heart, and lungs; the liver appears to be the principal target of oral exposure.

E.4.3.37.2 Carcinogenicity

Data regarding the carcinogenicity of trans-1,2-dichloroethene were not located.

E.4.3.38 Dichlorofluoromethane**E.4.3.38.1 Noncancer Toxicity**

Acute inhalation exposure of laboratory animals to high levels of dichlorofluoromethane produced CNS depression and narcosis, possible lung and liver pathology, and cardiac sensitization (ACGIH 1991). Prolonged inhalation exposure was associated with severe liver damage and cirrhosis and fetal loss. Neither oral nor inhalation RfD or RfC values were located for dichlorofluoromethane. The CNS, liver, lung and heart are the target organs for inhalation exposure to dichlorofluoromethane.

E.4.3.38.2 Carcinogenicity

Data were not located regarding the carcinogenicity of dichlorofluoromethane.

E.4.3.39 Diethyl Phthalate**E.4.3.39.1 Noncancer Toxicity**

Diethyl phthalate appears to have a low order of chronic oral toxicity. Reduced food intake and growth rate were the only effects observed in rats fed a diet containing 5 percent diethyl phthalate (3160 mg/kg bw-day) for 16 weeks (Brown et al. 1978). No effects were observed in rats similarly treated with 1 percent in the diet (750 mg/kg bw-day). In a two-year study, retarded growth and reduced food efficiency were observed in rats fed a diet containing 5 percent diethyl phthalate (Food Research Laboratories, Inc. 1955). No effects were observed in rats similarly fed a diet containing 2.5 percent diethyl phthalate. Intraperitoneal injection of pregnant rats induced mild developmental effects (Singh et al. 1972).

The acute oral toxicity of diethyl phthalate is very low; the LD_{50/30} in rats was 9500 to 31,000 mg/kg (ACGIH 1991). Repeated oral treatment reduced food intake, body weight gain, and food efficiency (body weight gain/unit food intake), and altered organ weights, but produced no histopathologic lesions (EPA 1993a). Based on an NOAEL for decreased weight gain and altered organ weights in a subchronic dietary study in rats and an uncertainty factor of 1000, EPA (1993a) derived a verified chronic oral RfD of 0.8 mg/kg/day. A provisional subchronic oral RfD of 8 mg/kg/day was based on the same NOAEL and an uncertainty factor of 100 (EPA 1992b). The data were not sufficient to identify target organs for the toxicity of diethyl phthalate.

The EPA (1993a) derived an RfD of 0.8 mg/kg/day for chronic oral exposure from the NOAEL of 750 mg/kg/day in the 16-week feeding study in rats (Brown et al. 1978). An uncertainty factor of 1000

7871

was applied with factors of 10 each for inter- and intraspecies variation, and to expand from subchronic to chronic exposure.

E.4.3.39.2 Carcinogenicity

The EPA (1993a) classifies diethyl phthalate as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans) on the basis of no cancer data in humans and inadequate cancer data in animals. The only long-term studies, the 16-week and 2-year dietary studies described above, were not designed to measure carcinogenicity. Quantitative risk estimates are not derived for Group D compounds.

E.4.3.40 2,4-Dimethylphenol

E.4.3.40.1 Noncancer Toxicity

Little is known about the toxicity of 2,4-dimethylphenol. The EPA (1993a) presented a chronic oral RfD of 0.02 mg/kg/day based on an NOAEL for nervous system effects and blood alterations in orally treated mice and an uncertainty factor of 3000. The EPA (1992b) presented a subchronic oral RfD of 0.2 mg/kg/day based on the same NOAEL and an uncertainty factor of 300. The nervous system and blood may be target organs for the oral toxicity of 2,4-dimethylphenol.

E.4.3.40.2 Carcinogenicity

Data were not located regarding the carcinogenicity of 2,4-dimethylphenol.

E.4.3.41 Di-n-octylphthalate

E.4.3.41.1 Noncancer Toxicity

The oral LD_{50/30} for di-n-octylphthalate in mice was 6513 mg/kg (Sax 1984). Intraperitoneal injection in rats during organogenesis induced teratogenicity. The EPA (1992b) presented a provisional chronic and subchronic oral RfD of 0.02 mg/kg/day, based on an LOAEL for increased liver and kidney weight and serum biochemical evidence of liver damage in a dietary study in rats. An uncertainty factor of 1000 was used. The data suggested that the liver, kidney, and fetus are the target organs for the toxicity of di-n-octylphthalate.

E.4.3.41.2 Carcinogenicity

Data were not located regarding the carcinogenicity of di-n-octylphthalate.

E.4.3.42 1,4-Dioxane

E.4.3.42.1 Noncancer Toxicity

The acute oral toxicity of 1,4-dioxane is low; LD_{50/30} values in laboratory animals ranged from 2000 to 6000 mg/kg (ACGIH 1991). Repeated oral exposure was associated with severe liver and kidney pathology. Inhalation studies in laboratory animals failed to identify adverse effects. Liver and kidney pathology were observed in workers exposed to high levels in the air. Neither oral nor inhalation RfD or RfC values were located for 1,4-dioxane. The target organs for oral exposure to 1,4-dioxane are the liver and kidney.

E.4.3.42.2 Carcinogenicity

Cancer studies consistently associated drinking water exposure of rats to 1,4-dioxane with increased incidence of nasal cavity and liver tumors (EPA 1993a). Drinking water exposure of mice resulted in increased incidence of liver tumors. An inhalation study in rats was negative. Occupational studies are inadequate to implicate 1,4-dioxane as a human carcinogen. On the basis of sufficient evidence for carcinogenicity in animals and inadequate evidence in humans, 1,4-dioxane is classified a cancer weight-of-evidence Group B2 compound (probable human carcinogen). The EPA (1993a) derived an oral slope factor of 0.011 per mg/kg/day, based on carcinomas of the nasal turbinates in orally exposed rats. Risk associated with inhalation exposure was not estimated.

E.4.3.43 Ethyl Benzene

E.4.3.43.1 Noncancer Toxicity

Subchronic to chronic oral or inhalation exposure of laboratory animals to ethyl benzene induced mild liver and kidney lesions (EPA 1993a). Acute inhalation exposure induced irritation of the mucous membranes in animals and humans, and prolonged inhalation exposure induced testicular degeneration in rabbits and monkeys (ACGIH 1991). The EPA (1993a) presented a verified chronic oral RfD for ethyl benzene of 0.1 mg/kg/day based on an NOEL for liver and kidney toxicity in female rats in a subchronic gavage study and an uncertainty factor of 1000. The EPA (1992b) presented a provisional subchronic oral RfD of 1 mg/kg/day based on the same NOEL and an uncertainty factor of 100. The EPA (1993a) also presented a verified chronic inhalation RfC of 1 mg/m³ derived from studies on developmental effects in rats and rabbits and an uncertainty factor of 300. The same value was adopted as the provisional subchronic inhalation exposure (EPA 1992b). The inhalation RfC is equivalent to 0.3 mg/kg/day, assuming humans inhale 20 m³ of air/day and weigh 70 kg. Target organs for exposure to ethyl benzene include the liver, kidneys, and testes, and, for inhalation exposure, the mucous membranes.

E.4.3.43.2 Carcinogenicity

Ethyl benzene is classified as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans) (EPA 1993a) based on an absence of human or animal cancer studies. Quantitative estimates are not derived for Group D chemicals.

E.4.3.44 Ethyl Parathion (Parathion)

Ethyl parathion is generally known by its synonym, parathion (EPA 1993a).

E.4.3.44.1 Noncancer Toxicity

Parathion is a cholinesterase inhibitor that produces signs and symptoms of muscarinic stimulation (parasympathetic stimulation: increased secretion, bronchial constriction, miosis, GI cramps, and diarrhea) and nicotinic stimulation followed by blockade (tachycardia, hypertension, muscle fasciculation, tremors, muscle weakness, flaccid paralysis) (Ecobichon 1991). In occupational exposure, reduced blood cholinesterase activity is a more sensitive endpoint than symptoms of toxicity (ACGIH 1986). The EPA (1992b) presented a provisional chronic and subchronic oral RfD of 0.006 mg/kg/day, based on an NOAEL for decreased erythrocyte cholinesterase activity in orally dosed humans and an uncertainty factor of 10. The target organ for parathion is the nervous system.

E.4.3.44.2 Carcinogenicity

The EPA (1993a) classifies parathion as a cancer weight-of-evidence Group C compound (possible human carcinogen), based on no human data and an increased frequency of adrenal cortical and thyroid tumors observed in a dietary study in rats. Quantitative risk estimates were not available.

E.4.3.45 2-Hexanone (methyl n-butyl ketone)**E.4.3.45.1 Noncancer Toxicity**

The acute oral toxicity of 2-hexanone is low, with an oral LD_{50/30} for rats of 2600 mg/kg (ACGIH 1986). The classic effect of occupational (dermal and inhalation) exposure to 2-hexanone is peripheral neuropathy. The same effect was observed in inhalation experiments with laboratory animals. The data are inadequate for derivation of oral or inhalation RfD or RfC values (EPA 1992b). The peripheral nerves are the target organ for the toxicity of 2-hexanone.

E.4.3.45.2 Carcinogenicity

Data were not located regarding the carcinogenicity of 2-hexanone.

E.4.3.46 Isobutyl Alcohol

E.4.3.46.1 Noncancer Toxicity

Oral or inhalation exposure to isobutyl alcohol induced CNS depression, liver and kidney effects, and decreased erythrocyte count in laboratory animals (ACGIH 1986; EPA 1993a). The EPA (1993a) presented a verified chronic oral RfD of 0.3 mg/kg/day based on an NOEL for CNS effects in orally treated rats and an uncertainty factor of 1000. The EPA (1992b) presented a provisional subchronic oral RfD of 3 mg/kg/day based on the same NOEL and an uncertainty factor of 100. Target organs for the toxicity of isobutyl alcohol are the CNS, liver, kidney, and erythrocyte.

E.4.3.46.2 Carcinogenicity

Data regarding the carcinogenicity of isobutyl alcohol were not located.

E.4.3.47 Lead

E.4.3.47.1 Pharmacokinetics

Studies in humans indicate that an average of 10 percent of ingested lead is absorbed, but estimates as high as 40 percent were obtained in some individuals (Tsuchiya 1986). Nutritional factors have a profound effect on GI absorption efficiency. Children absorb ingested lead more efficiently than adults; absorption efficiencies up to 53 percent were recorded for children three months to eight years of age. Similar results were obtained for laboratory animals; absorption efficiencies of 5 to 10 percent were obtained for adults and ≥ 50 percent were obtained for young animals. The deposition rate of inhaled lead averages approximately 30 to 50 percent, depending on particle size, with as much as 60 percent deposition of very small particles ($0.03 \mu\text{m}$) near highways. All lead deposited in the lungs is eventually absorbed.

Approximately 95 percent of the lead in the blood is located in the erythrocytes (EPA 1990c). Lead in the plasma exchanges with several body compartments, including the internal organs, bone, and several excretory pathways. In humans, lead concentrations in bone increase with age (Tsuchiya, 1986). About 90 percent of the body burden of lead is located in the skeleton. Neonatal blood concentrations are about 85 percent of maternal concentrations (EPA 1990c). Excretion of absorbed lead is principally through the urine, although GI secretion, biliary excretion, and loss through hair, nails, and sweat are also significant.

E.4.3.47.2 Noncancer Toxicity

The noncancer toxicity of lead to humans has been well characterized through decades of medical observation and scientific research (EPA 1993a). The principal effects of acute oral exposure are colic with diffuse paroxysmal abdominal pain (probably due to vagal irritation), anemia, and, in severe cases, acute encephalopathy, particularly in children (Tsuchiya 1986). The primary effects of long-

term exposure are neurological and hematological. Limited occupational data indicate that long-term exposure to lead may induce kidney damage. The principal target organs of lead toxicity are the erythrocyte and the nervous system. Some of the effects on the blood, particularly changes in levels of certain blood enzymes, and subtle neurobehavioral changes in children, appear to occur at levels so low as to be considered nonthreshold effects.

EPA (1992b) presents no inhalation RfC for lead, but referred to the National Ambient Air Quality Standard (NAAQS) for lead, which could be used in lieu of an inhalation RfC. The NAAQSs are based solely on human health considerations and are designed to protect the most sensitive subgroup of the human population. The NAAQS for lead is $1.5 \mu\text{g}/\text{m}^3$, averaged quarterly (EPA 1992b). The NAAQS is equivalent to $0.00043 \text{ mg}/\text{kg}/\text{day}$, assuming a body weight of 70 kg and an inhalation rate of $20 \text{ m}^3/\text{day}$.

The EPA (1990c, 1993a) determined that it is inappropriate to derive an RfD for oral exposure to lead for several reasons. First, the use of an RfD assumes that a threshold for toxicity exists, below which adverse effects are not expected to occur; however, the most sensitive effects of lead exposure, impaired neurobehavioral development in children and altered blood enzyme levels associated with anemia, may occur at blood lead concentrations so low as to be considered practically nonthreshold in nature. Second, RfD values are specific for the route of exposure for which they are derived. Lead, however, is ubiquitous, so that exposure occurs from virtually all media and by all pathways simultaneously, making it practically impossible to quantify the contribution to blood lead from any one route of exposure. Finally, the dose-response relationships common to many toxicants, and upon which derivation of an RfD is based, do not hold true for lead. This is because the fate of lead within the body depends, in part, on the amount and rate of previous exposures, the age of the recipient, and the rate of exposure. There is, however, a reasonably good correlation between blood lead concentration and effect. Therefore, blood lead concentration is the appropriate parameter on which to base the regulation of lead.

The EPA UBK lead model is an iterated set of equations that estimate blood lead concentration in children aged 0 to 7 years (EPA 1990c; 1991c). The biokinetic part of the model describes the movement of lead between the plasma and several body compartments and estimates the resultant blood lead concentration. The rate of the movement of lead between the plasma and each compartment is a function of the transition or residence time (i.e., the mean time for lead to leave the plasma and enter a given compartment, or the mean residence time for lead in that compartment). Compartments modeled include the erythrocytes, liver, kidneys, all the other soft tissue of the body, cortical bone, and trabecular bone. Excretory pathways and their rates are also modeled. These include the mean time for excretion from the plasma to the urine, from the liver to the bile, and from the other soft tissues to the hair, skin, sweat, etc. The model permits the user to adjust the transition and residence times.

At the time the Operable Unit 1 baseline risk assessment was completed, a final version of the EPA UBK model and guidance for its use in Superfund risk assessment was not available. Considering the current limitations of the EPA UBK model, it was not applied in the assessment of health effects of lead for Operable Unit 1.

EPA guidance (EPA, 1989k) establishes an interim soil cleanup level for lead of 500 to 1000 parts per million (ppm) to be applied at Superfund sites. This range is considered by EPA to be protective for direct contact with lead-contaminated soils in residential settings. The guidance adopts recommendations of the Centers for Disease Control and is to be followed when current or predicted land use is residential.

In more recent guidance (EPA 1991i) EPA states that they are seeking resolution of specific technical concerns before issuing a directive recommending the UBK model as the preferred method for setting lead cleanup levels at CERCLA sites. The model is under review by the Science Advisory Board, and a guidance manual is under development.

E.4.3.47.3 Carcinogenicity

EPA (1993a) classifies lead in cancer weight-of-evidence Group B2 (probable human carcinogen), based on inadequate evidence of cancer in humans and sufficient animal evidence. The human data consist of several epidemiologic occupational studies that yielded confusing results. All of the studies lacked quantitative exposure data and failed to control for smoking and concomitant exposure to other possibly carcinogenic metals. Rat and mouse bioassays showed statistically significant increases in renal tumors following dietary and subcutaneous exposure to several soluble lead salts. Various lead compounds were observed to induce chromosomal alterations in vivo and in vitro, sister chromatid exchange in exposed workers, and cell transformation in Syrian hamster embryo cells; to enhance simian adenovirus induction; and to alter molecular processes that regulate gene expression. EPA (1993a) declined to estimate risk for oral exposure to lead because many factors (e.g., age, general health, nutritional status, existing body burden and duration of exposure) influence the bioavailability of ingested lead, introducing a great deal of uncertainty into any estimate of risk.

E.4.3.48 Malathion

E.4.3.48.1 Noncancer Toxicity

Malathion is an organic phosphorothioate that induces parasympathetic and CNS effects by inhibiting acetylcholinesterase activity at the nerve synapse (Ecobichon 1991). The acute oral toxicity of malathion is low, with an LD_{50/30} in rats of approximately 2100 mg/kg (ACGIH 1986). Acute effects include GI cramps, diarrhea, salivation, muscle fasciculations, and tremors. Effects are preceded by reduced cholinesterase activity in the tissues, particularly in the erythrocytes and plasma. Symptoms in intoxicated humans included CNS symptoms such as emotional instability, confusion, and memory loss

consistent with cholinesterase inhibition. Fatal cases showed damage to the myocardium and the pericardial blood vessels.

Effects observed in prolonged oral exposure studies in laboratory animals included reduced body weights and cholinesterase inhibition (EPA 1993a). The EPA (1993a) derived an RfD of 0.02 mg/kg/day for chronic oral exposure from an NOEL of 0.23 mg/kg/day for erythrocyte cholinesterase inhibition in human volunteers ingesting 16 mg/day for 47 days (Moeller and Rider 1962). An uncertainty factor of 10 was applied to account for variations in sensitivity within the human population. The EPA (1992b) presented the same value as a provisional subchronic oral RfD. The target organs for the toxicity of malathion are the nervous system and the heart.

E.4.3.48.2 Carcinogenicity

Malathion has not yet been reviewed by the EPA for evidence of carcinogenicity to humans (EPA 1993a).

E.4.3.49 Manganese

E.4.3.49.1 Noncancer Toxicity

Manganese is nutritionally required in humans for normal growth and health (EPA 1993a). Humans exposed to approximately 0.8 mg manganese/kg/day in drinking water exhibited lethargy, mental disturbances (1/16 committed suicide), and other neurologic effects. The elderly appeared to be more sensitive than children. Oral treatment of laboratory rodents induced biochemical changes in the brain, but rodents did not exhibit the neurological signs exhibited by humans. Occupational exposure to high concentrations in air induced a generally typical spectrum of neurological effects, and increased incidence of pneumonia (ACGIH 1986).

Very recently, the chronic oral RfD for manganese was removed from IRIS (EPA 1993a). The subchronic oral RfD presented by EPA (1992b) was the same value as the chronic oral RfD. It seems prudent to remove the subchronic oral RfD as well, to reflect EPA's lack of confidence in this derivation. The EPA (1993a) presented a verified chronic inhalation RfC of 0.0004 mg/m³ based on an LOAEL for respiratory symptoms and psychomotor disturbances in occupationally exposed humans and an uncertainty factor of 900. The EPA (1992b) presented the same value as a subchronic inhalation RfC. The inhalation RfC is equivalent to 0.0001 mg/kg/day, assuming humans inhale 20 m³ of air/day and weigh 70 kg. The CNS and respiratory tract are target organs of inhalation exposure to manganese.

E.4.3.49.2 Carcinogenicity

The EPA (1993a) classifies manganese in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans). Quantitative cancer risk estimates are not derived for Group D chemicals.

E.4.3.50 Mercury

Mercury occurs in three forms: elemental, organic, and inorganic. Although the toxicity of all forms is mediated by the mercury cation, the extent of absorption and pattern of distribution within the body, which determines the effects observed, depends on the form to which the organism is exposed (Goyer 1991). Bacterial activity in the environment converts inorganic mercury to methyl mercury (Berlin 1986a). It is likely that either inorganic mercury or methyl mercury may be taken up by plants and enter the food chain, and this discussion will focus on inorganic and methyl mercury. Exposure to elemental mercury, which is more likely to occur in an occupational setting, is not discussed herein.

E.4.3.50.1 Pharmacokinetics

The GI absorption of inorganic mercury salts is about 2 to 10 percent in humans, and slightly higher in experimental animals (Berlin 1986a; Goyer 1991). Inorganic mercury in the blood is roughly equally divided between the plasma and erythrocytes. Distribution is preferentially to the kidney, with somewhat lower concentrations found in the liver, and even lower levels found in the skin, spleen, testes, and brain (Berlin 1986a). Inorganic mercury is excreted principally through the feces and urine, with minor pathways including the secretions of exocrine glands and exhalation of elemental mercury vapor.

Methyl mercury is nearly completely (90 to 95 percent) absorbed from the GI tract (Berlin 1986a). The concentration of methyl mercury in the erythrocytes is about 10 times that in the plasma. Methyl mercury leaves the blood slowly, showing particular affinity for the brain, particularly in primates. In rats, 1 percent of the body burden of methyl mercury is found in the brain, but in humans, 10 percent of the body burden is found in the brain. Somewhat lower levels are found in the liver and kidney. During pregnancy, methyl mercury accumulates in the fetal brain, often at levels higher than in the maternal brain. Most tissues except the brain transform methyl mercury to inorganic mercury. Excretion of methyl mercury is principally via the bile, with a half-life of 70 days in humans not suffering from toxicity. Following exposure to methyl mercury, some of the mercury in the bile exists as methyl mercury and some as the inorganic form. The inorganic form is largely passed in the feces, but the methyl mercury is subject to enterohepatic recirculation. Another important excretory pathway for methyl mercury is lactation.

E.4.3.50.2 Noncancer Toxicity

Target organs for inorganic or methyl mercury include the kidney, nervous system, fetus, and neonate. Acute oral exposure to high doses of inorganic mercury causes severe damage to the GI mucosa

because of the corrosive nature of mercury salts, which may lead to bloody diarrhea, shock, circulatory collapse, and death (Berlin 1986a; Goyer 1991). Acute sublethal poisoning induces severe kidney damage. Chronic exposure induces an autoimmune glomerular disease and renal tubular injury. The EPA (1992b) presented a verified RfD of 0.3 $\mu\text{g}/\text{mg}\cdot\text{day}$ for chronic oral exposure to inorganic mercury, based on kidney effects in rats.

Acute or chronic exposure to methyl mercury leads to neurologic dysfunction (Berlin 1986a; Goyer 1991). The region of the nervous system affected is species-dependent. Methyl mercury poisoning in rats induces peripheral nerve damage and kidney effects. In humans, the sensory cortex appears to be the most sensitive. The brain of the fetus and the neonate may be unusually sensitive to methyl mercury; retarded neurologic development was observed in prenatally exposed children whose mothers showed no clinical signs of poisoning. The EPA (1993a) derived an RfD of 0.3 $\mu\text{g}/\text{kg}/\text{day}$ for chronic oral exposure to methyl mercury based on neurological effects in environmentally exposed humans. In this derivation, an intake of 3 $\mu\text{g}/\text{kg}/\text{day}$ was an LOAEL corresponding to a blood level of 200 ng/mL , which was associated with CNS effects. An uncertainty factor of 10 was used to estimate an NOAEL from an LOAEL.

E.4.3.50.3 Carcinogenicity

The EPA (1993a) classifies inorganic mercury in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans), based on no data regarding cancer in humans, and inadequate animal and supporting data. In an intraperitoneal injection study with metallic mercury in rats, sarcomas developed only in those tissues in direct contact with the test material (Druckrey et al. 1957). A two-year dietary study in rats with mercuric acetate (inorganic mercury) yielded no evidence of carcinogenicity (Fitzhugh et al. 1950). In mice, however, dietary exposure to high doses of mercury chloride for up to 78 weeks induced renal adenomas and adenocarcinomas (Mitsumori et al. 1981). The EPA has not yet evaluated the carcinogenicity of organic mercury. No carcinogenic effect, however, was observed in a two-year feeding study with phenylmercuric acetate in rats (Fitzhugh et al. 1950).

E.4.3.51 Methylene Chloride

E.4.3.51.1 Noncancer Toxicity

Occupational exposure to high concentrations of methylene chloride may induce liver damage (ACGIH 1986). Liver effects were induced in animals by inhalation or oral exposure (EPA 1993a). The EPA (1993a) presented a verified chronic oral RfD for methylene chloride of 0.06 $\text{mg}/\text{kg}/\text{day}$ based on an NOAEL for liver toxicity in male and female rats in chronic drinking water studies and an uncertainty factor of 100. The EPA (1992b) presented the same value as a provisional subchronic oral RfD. The EPA (1992b) also presented a provisional subchronic and chronic inhalation RfC of 3 mg/m^3 , derived from an NOAEL for liver toxicity in a two-year intermittent exposure inhalation study in rats and an

uncertainty factor of 100. The inhalation RfC is equivalent to 0.9 mg/kg/day, assuming humans inhale 20 m³ of air/day and weigh 70 kg. The principal target organ for methylene chloride is the liver.

E.4.3.51.2 Carcinogenicity

Methylene chloride is classified in EPA cancer weight-of-evidence Group B2 (probable human carcinogen), based on inadequate human data and sufficient evidence of carcinogenicity in animals (EPA 1993a). Animal inhalation studies showed increased incidence of hepatocellular neoplasms and alveolar/bronchiolar neoplasms in male and female mice, mammary tumors in rats of either sex, salivary gland sarcomas in male rats, and leukemia in female rats. Oral studies were inconclusive. An oral slope factor of 0.0075 per mg/kg/day was based on the incidence of liver tumors in two inhalation studies in mice. An inhalation unit risk of 4.7E-07 per µg/m³ was based on the incidence of liver and lung tumors in one inhalation study. The inhalation unit risk is equivalent to 0.0016 per mg/kg/day, based on inhaled dose, assuming humans inhale 20 m³ of air/day and weigh 70 kg.

E.4.3.52 2-Methylnaphthalene

E.4.3.52.1 Noncancer Toxicity

Data located regarding the noncancer toxicity of 2-methylnaphthalene are limited to an oral lowest dose associated with lethality (LD₅₀) in rats of 5000 mg/kg (Sax 1984). Neither oral nor inhalation RfD or RfC values were located.

E.4.3.52.2 Carcinogenicity

Data regarding the carcinogenicity of 2-methylnaphthalene were not located.

E.4.3.53 Methyl Parathion

E.4.3.53.1 Noncancer Toxicity

Methyl parathion inhibited cholinesterase activity in animals and humans, reduced erythrocyte count, hematocrit and blood hemoglobin concentration, and may have induced degeneration in the peripheral nerves of laboratory animals (EPA 1993a). The EPA (1993a) presented a verified RfD of 0.00025 mg/kg/day for chronic oral exposure based on an NOEL for cholinesterase inhibition and effects on the erythrocytes in a two-year dietary study in rats. An uncertainty factor of 100 was used. The EPA (1992b) presented the same value as a provisional subchronic oral RfD. Target organs of methyl parathion are the erythrocyte and nervous system.

E.4.3.53.2 Carcinogenicity

Data regarding the carcinogenicity of methyl parathion were not located.

E.4.3.54 4-Methyl-2-Pentanone (Methyl Isobutyl Ketone)

The compound 4-methyl-2-pentanone is more commonly known by its synonym, methyl isobutyl ketone (MIBK).

E.4.3.54.1 Noncancer Toxicity

The acute toxicity of MIBK is low; oral LD_{50/30} values in rats, mice, and guinea pigs ranged from 1600 to approximately 4600 mg/kg (Krasavage et al. 1982). In a 13-week gavage study in rats, 50 mg/kg/day was an NOEL for liver and kidney effects (EPA 1992b). Acute exposure of laboratory animals to high concentrations in air induced narcosis and death (Krasavage et al. 1982). Repeated inhalation exposures induced CNS effects and increased the kidney- and liver-to-body-weight ratios. Occupational exposure was associated with CNS and GI effects, and, at high concentrations, ocular irritation (ACGIH 1986).

The EPA (1992b) presented a provisional chronic oral RfD of 0.05 mg/kg/day based on the oral NOEL in rats and an uncertainty factor of 1000. The same NOEL and an uncertainty factor of 100 was the basis of a provisional subchronic oral RfD of 0.5 mg/kg/day. A provisional chronic inhalation RfC of 0.08 mg/m³ was based on an NOEL for increased kidney and liver weights in a 90-day inhalation study in rats and an uncertainty factor of 1000. A provisional subchronic inhalation RfC of 0.8 mg/m³ was derived from the same inhalation NOEL and an uncertainty factor of 100. The chronic and subchronic inhalation RfC values are equivalent to 0.02 and 0.2 mg/kg/day, respectively, assuming an inhalation rate of 20 m³/day and a body weight of 70 kg for humans. The principal target organ for MIBK is the CNS.

E.4.3.54.2 Carcinogenicity

Data were not located regarding the carcinogenicity of MIBK.

E.4.3.55 2-Methylphenol (o-cresol)**E.4.3.55.1 Noncancer Toxicity**

The oral toxicity of 2-methylphenol is low; the LD_{50/30} in rats was 1350 mg/kg (ACGIH 1991). Ingestion by animals or humans of mixed isomers of methylphenol was associated with corrosion of the GI tissues, kidney tubular, pancreatic and liver damage, and nodular pneumonia. Occupational exposure of humans or inhalation exposure of animals to mixed isomers of methylphenol was associated with neurological effects, impaired kidney function, and irritation of the respiratory tract. The EPA (1993a) presented a verified chronic oral RfD of 0.05 mg/kg/day based on an NOAEL for decreased body weight and neurotoxicity in a gavage study in rats and an uncertainty factor of 1000. The EPA (1992b) presented a subchronic oral RfD of 0.5 mg/kg/day based on the same NOAEL and an uncertainty factor of 100. Principal target organs are the nervous system, respiratory mucosa, liver, and kidney.

E.4.3.55.2 Carcinogenicity

Methylphenol isomers were tumor promoters in the two-stage mouse skin tumor initiation-promotion test (ACGIH 1991). The EPA (1993a) classified 2-methylphenol as a cancer weight-of-evidence Group C compound (possible human carcinogen), but derived no quantitative risk estimates for either oral or inhalation exposure.

E.4.3.56 3-Methylphenol

E.4.3.56.1 Noncancer Toxicity

The compound 3-methylphenol is often known by its primary synonym, m-cresol. The chemical produced CNS effects (salivation, urination, tachypnea, hypoactivity, tremors) and reduced food consumption and growth rate in rats treated by gavage for 90 days (EPA 1986a, 1987b). There appeared to be no functional or morphologic effects on the other organs of the body. The EPA (1992b) derived an RfD of 0.05 mg/kg/day from an NOAEL of 50 mg/kg/day in the 90-day rat study (EPA 1986a, 1987b). An uncertainty factor of 1000 was applied with factors of 10 each for inter- and intraspecies variation, and to expand from subchronic to chronic exposure.

Inhalation data are limited to a study that associated exposure to approximately 6 to 9 mg/m³ with hematopoietic and respiratory tract effects in rats and nasopharyngeal irritation in humans (Uzhdavini et al. 1972). The data were insufficient for derivation of an RfC for chronic inhalation exposure (EPA 1992b).

E.4.3.56.2 Carcinogenicity

The EPA (1993a) classifies 3-methylphenol as a cancer weight-of-evidence Group C compound (possible human carcinogen), based on inadequate data in humans and limited data for carcinogenicity in animals. The human data consist of anecdotal data associating occupational exposure with a case of carcinoma of the urinary bladder and a case of carcinoma of the vocal cords, but a causal association is not credible. Animal studies identify 3-methylphenol as a tumor promoter in the two-stage skin-painting assay in mice, but the data were not sufficient for quantitative risk estimation.

E.4.3.57 4-Methylphenol (p-cresol)

E.4.3.57.1 Noncancer Toxicity

The oral toxicity of 4-methylphenol is low; the LD_{50/30} in rats is 1800 mg/kg (ACGIH 1991). Ingestion by animals or humans of mixed isomers of methylphenol was associated with corrosion of the GI tissues, kidney tubular, pancreatic and liver damage, and nodular pneumonia. Occupational exposure of humans or inhalation exposure of animals to mixed isomers of methylphenol was associated with neurological effects, impaired kidney function and irritation of the respiratory tract. The EPA (1992b) presented a provisional chronic oral RfD of 0.05 mg/kg/day based on an NOAEL

for decreased body weight and neurotoxicity in a gavage study in rats and an uncertainty factor of 1000. The EPA (1992b) also presented a provisional subchronic oral RfD of 0.5 mg/kg/day based on the same NOAEL and an uncertainty factor of 100. Principal target organs are the nervous system, respiratory mucosa, liver and kidney.

E.4.3.57.2 Carcinogenicity

Methylphenol isomers are tumor promoters in the two-stage mouse skin tumor initiation-promotion test (ACGIH 1991). The EPA (1993a) classifies 2-methylphenol as a cancer weight-of-evidence Group C compound (possible human carcinogen), but derives no quantitative risk estimates for either oral or inhalation exposure.

E.4.3.58 Molybdenum

E.4.3.58.1 Noncancer Toxicity

Molybdenum is a nutritionally essential trace element involved in copper and sulfur metabolism (Friberg and Lener 1986). Chronic molybdenum poisoning in livestock (heart disease) results from a molybdenum-copper imbalance and is characterized by anemia, GI disturbances, bone disorders, and growth depression. In laboratory animals, excess molybdenum induced effects in the liver, kidneys, and spleen. Gout-like symptoms were observed in humans living in a high molybdenum, low copper area. A few cases of pneumoconiosis were reported in occupationally exposed workers. The EPA (1992b) presented a provisional chronic oral RfD of 0.005 mg/kg/day based on an LOAEL in humans exposed to high levels in water and diet and an uncertainty factor of 30. A provisional subchronic oral RfD of 0.04 mg/kg/day was based on an NOAEL for biochemical changes in the blood of humans exposed to high levels in water and an uncertainty factor of 1000. Target organs for molybdenum toxicity include the erythrocyte, liver, and kidney.

E.4.3.58.2 Carcinogenicity

Data regarding the carcinogenicity of molybdenum were not located.

E.4.3.59 Neptunium

Neptunium is the element of atomic number 93, just beyond uranium in the periodic table. Neptunium isotopes have not presented unusual problems in occupational radiation protection, nor have they, until recently, been of special environmental concern. Attention has recently been directed to the potential environmental exposure to the long-lived NP-237, which is estimated to be the principal surviving component of high level nuclear waste after ten or twenty thousand years. Np-237 has a half-life of 2.14×10^6 years, and is primarily produced in nuclear reactors via the (n,2n) and (n,8) nuclear reactions with uranium. Its presence in the high-level nuclear waste, and its presumed environmental mobility, has made it an isotope with special environmental concern. It has been estimated that Np-

237 may be the most hazardous remaining constituent of high-level nuclear waste during the interval from 10,000 to 30,000 years following disposal.

E.4.3.59.1 Pharmacokinetics

The fraction of ingested neptunium absorbed from the gastrointestinal tract into blood (F_1) is currently assumed to be 0.01 (ICRP, 1980). This value was based on experimental data involving a large group of rats which were fed with doses of neptunium exceeding 1 mg/kg. When the dietary dose is lower than 1 mg/kg, the fraction F_1 was in order of 0.001 or less. Data on distribution and retention of neptunium in rats indicate that its metabolic behavior is similar to that of plutonium. However, there are some indications that neptunium may distribute more like calcium than like plutonium in the skeleton. Forty-five percent of the neptunium leaving the transfer compartment will be translocated to mineral bone. Another 45 percent will be transported to the liver, and 0.035 percent or 0.011 percent to the testes or to the ovaries, respectively. The remaining neptunium leaving the transfer compartment is assumed to go directly to excreta. The biological half-life of neptunium is about 100 years in mineral bone, about 40 years in the liver, and it is assumed that neptunium is permanently retained in the gonads. These retention and translocation data were based on the ICRP common model for systemic distribution and retention of all transuranic elements. The model itself was largely based on plutonium data.

E.4.3.59.2 Noncancer Toxicity

All animal toxicity studies with neptunium have employed Np-237. Because of its low specific activity (0.76 mCi/g), the chemical toxicity effects of Np-237 are often observed to the exclusion of radiation effects. Soviet data in this area were studied by Moskaev et al (NCRP, 1988). The concern was not with the chemical effects. Although such effects might be a controlling factor in an acute exposure to Np-237, they would not be an important factor at the usual levels of concern in radiation protection, and certainly not at the very low levels of potential environmental exposure. Therefore, health effects are assessed only with respect to carcinogenicity.

E.4.3.59.3 Carcinogenicity

Effects of neptunium exposure have not been studied in man. For radiation protection purposes it was assumed that radiation dose resulting from neptunium deposition in organs and tissues will result in biomedical effects similar to those observed following the exposure of humans to other sources of ionizing radiation. The very limited data on neptunium effects in animals provide no direct useful estimates of risk to humans. These data play no direct role in establishing neptunium standards, they can nevertheless help to validate these standards through comparisons with other animal studies employing other radionuclides.

Long-term radiation effects of NP-237 have been studied only in rats. Genetic effects have not been studied. Bone cancer has been the predominant long-term effect of low-level injections of Np-237;

both lung and bone cancer incidences are elevated following inhalation exposure. There is no indication that neptunium at low exposure levels constitutes a unique health risk unpredictable from its general radiological characteristics.

The annual limits of intake of Np-237 as recommended by NCRP (1987 NCRP recommendations for annual limits on intake) are as follows:

Oral ingestion	0.6 μ Ci	based on non-stochastic limits
	2.0 μ Ci	based on stochastic limits
Inhalation	0.005 μ Ci	based on non-stochastic limits
	0.010 μ Ci	based on stochastic limits

The non-stochastic limit or dose equivalent applies to bone surface.

E.4.3.60 Nickel

E.4.3.60.1 Noncancer Toxicity

In a subchronic gavage study with nickel chloride in water, clinical signs of toxicity in rats included lethargy, ataxia, irregular breathing, reduced body temperature, salivation, and discolored extremities (EPA 1993a). Inhalation exposure was associated with asthma and pulmonary fibrosis in welders using nickel alloys (ACGIH 1986). Lung effects were observed in laboratory animals exposed by inhalation. The EPA (1993a) presented a verified RfD of 0.02 for chronic oral exposure to nickel, based on an NOAEL for decreased organ and body weights in a two-year dietary study with nickel sulfate in rats and an uncertainty factor of 300. The EPA (1992b) presented the same value as a provisional subchronic oral RfD. The CNS appears to be the target organ for the oral toxicity of nickel. The lung is clearly the target organ for inhalation exposure.

E.4.3.60.2 Carcinogenicity

Occupational exposure to nickel was associated with increased risk of nasal, laryngeal and lung cancer (ATSDR 1988a). Inhalation exposure of rats to nickel subsulfide increased the incidence of lung tumors. The EPA (1993a) presents a cancer weight-of-evidence Group A classification (human carcinogen) for nickel, and presents an inhalation unit risk of 0.00024 per μ g/m³ for nickel refinery dust. The unit risk is equivalent to 0.84 per mg/kg/day, assuming humans inhale 20 m³ of air/day and weigh 70 kg. The quantitative estimate was derived from the human occupational studies.

E.4.3.61 Nitrate Nitrogen, Nitrite Nitrogen

E.4.3.61.1 Noncancer Toxicity

The oral toxicity of nitrate is mediated by its reduction to nitrite by the microflora of the GI tract (EPA 1993a). Nitrite induces oxidation of hemoglobin to methemoglobin, which is incapable of transporting oxygen from the lungs to the tissues. Human toxicity is generally associated with high levels of nitrate or nitrite in drinking water. Infants are the most sensitive members of the population. The EPA (1993a) presented a verified chronic oral RfD for nitrate of 1.6 mg nitrate nitrogen/kg/day, based on an NOAEL for methemoglobinemia in infants and an uncertainty factor of 1. The EPA (1993a) also presented a verified chronic oral RfD for nitrite of 0.1 mg nitrite nitrogen/kg/day, based on the same NOAEL and an uncertainty factor of 10. The EPA (1992b) adopted the chronic oral RfD for nitrite nitrogen as sufficiently protective for subchronic inhalation as well. The target tissue for the toxicity of nitrate or nitrite is the erythrocyte.

E.4.3.61.2 Carcinogenicity

Data regarding the carcinogenicity of uncombined nitrate or nitrite were not located. Nitrite can combine with secondary amines in food or other nitrogenous compounds to form nitrosamines or other N-nitroso compounds, many of which are important animal carcinogens (Menzer 1991).

E.4.3.62 N-nitrosodiphenylamine (Diphenylnitrosamine)

E.4.3.62.1 Noncancer Toxicity

The acute oral toxicity of N-nitrosodiphenylamine is low; oral LD_{50/30} values in rats and mice are 1650 and 3850 mg/kg, respectively (Sax 1984). Data regarding the noncancer effects of repeated oral or inhalation exposure were not located.

E.4.3.62.2 Carcinogenicity

The EPA (1993a) classifies N-nitrosodiphenylamine in cancer weight-of-evidence Group B2 (probable human carcinogen), based on inadequate human data and sufficient evidence for carcinogenicity in animals. A verified oral slope factor of 0.0049 per mg/kg/day was based on increased incidence of bladder tumors in a chronic drinking water study in rats.

E.4.3.63 4-Nitroaniline

E.4.3.63.1 Pharmacokinetics

Data regarding the extent of gastrointestinal absorption of 4-nitroaniline were not located in the available literature. Data regarding the dinitrobenzenes, however, suggest that absorption from the gastrointestinal tract may be substantial (EPA 1980b). 4-Nitroaniline is readily absorbed through the skin (ACGIH 1986). Lacking more quantitative data, default values for absorption efficiency of 0.9

for gastrointestinal absorption and 0.3 for dermal uptake from soil (EPA 1993d) appear to be reasonable.

E.4.3.63.2 Noncancer Toxicity

Oral LD₅₀ values of 810, 450, and 750 mg/kg were reported for mice, guinea pigs, and rats, respectively (Sax, N.I. 1984), which suggests moderate toxicity by the oral route. Acute effects in humans include neurologic symptoms consistent with methemoglobinemia and hemolytic anemia (ACGIH 1986; Sax 1984). Chronic effects in laboratory animals include liver pathology (Sax 1984). An oral RfD of 0.003 mg/kg-day was located, but the basis of this derivation is unclear (EPA 1993c). Data regarding inhalation exposure were not located.

E.4.3.63.3 Carcinogenicity

Data regarding the carcinogenicity of 4-nitroaniline were not located in the available literature.

E.4.3.64 4-Nitrophenol

E.4.3.64.1 Pharmacokinetics

Data regarding the pharmacokinetics of 4-nitrophenol were not located. EPA (1980) stated that the dinitrophenols are administrative. Lacking more quantitative data, default values for absorption efficiency of 0.9 for gastrointestinal absorption and 0.3 for dermal uptake from soil (EPA 1993c) appear to be reasonable.

E.4.3.64.2 Noncancer Toxicity

Oral LD₅₀ values of 467 and 350 mg/kg were reported for mice and rats, respectively (Sax, N.I. 1984), which suggests moderate toxicity by the oral routes. Chronic effects in laboratory animals include liver pathology, splenomegaly and neurologic signs (EPA 1980b). An oral RfD of 0.008 mg/kg-day was located, but the basis of this derivation is unclear (EPA 1993e). Data regarding inhalation exposure were not located.

E.4.3.64.3 Carcinogenicity

EPA (1993b) assigned 4-nitroaniline to EPA weight-of-evidence Group D, not classifiable as to carcinogenicity to humans.

E.4.3.65 Pentachlorophenol

E.4.3.65.1 Noncancer Toxicity

Acute inhalation exposure to mists or dusts of pentachlorophenol was associated with vascular damage culminating in heart failure (ACGIH 1986). Survivors suffered from impaired autonomic function, circulation, and vision. Chronic oral exposure was associated with liver and kidney lesions (EPA

1993a). The EPA (1993a) presented a verified chronic oral RfD of 0.03 mg/kg/day based on an NOAEL for liver and kidney effects in a chronic dietary study in rats and an uncertainty factor of 100. The EPA (1992b) presented the same value as a provisional subchronic oral RfD. Target organs for the toxicity of pentachlorophenol include the circulatory and nervous systems, and the liver and kidney.

E.4.3.65.2 Carcinogenicity

The EPA (1993a) classifies pentachlorophenol in cancer weight-of-evidence Group B2 (probable human carcinogen) on the basis of inadequate human data and sufficient animal data. The animal data consisted of dietary studies in mice that show an increased incidence of liver, adrenal and vascular tumors, and studies in rats that show no carcinogenic effect. The test material used in these studies was approximately 90 percent pure, and was contaminated with tri- and tetrachlorophenol, hexachlorobenzene, PCDDs, and PCDFs. The EPA (1993a) presented a verified oral slope factor of 0.12 per mg/kg/day, based on the incidence of liver, adrenal, and vascular tumors in orally exposed mice.

E.4.3.66 Phenol

E.4.3.66.1 Noncancer Toxicity

Oral LD_{50/30} values for phenol were 300 mg/kg in mice and 414 mg/kg in rats (Sax 1984). Subchronic and chronic oral exposure were associated with depressed growth rate, possibly due to decreased water or food intake, and kidney damage (EPA 1993a). The fetus appears to be more sensitive than adults, showing decreased body weights at doses that are not maternally toxic. Exposure of animals to phenol vapors was associated with damage to the lungs, heart, liver, and kidneys (ACGIH 1986). Phenol vapors are absorbed through the skin as readily as through the lungs. The EPA (1993a) presented a verified chronic oral RfD of 0.6 mg/kg/day, based on an NOAEL for reduced fetal body weight in rats treated by gavage and an uncertainty factor of 100. The EPA (1992b) presented the same value as a provisional RfD for subchronic oral exposure. The principal target organs for the toxicity of phenol are the kidney and the fetus.

E.4.3.66.2 Carcinogenicity

The EPA (1993a) classifies phenol in cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans), based on the absence of cancer data in humans and inadequate animal data. Quantitative risk estimates are not derived for Group D compounds.

E.4.3.67 Plutonium

Plutonium is a silvery-white radioactive metal that exists as a solid under normal conditions. There are several isotopes of plutonium, the most common ones are Pu-238 and Pu-239 with half-lives of 90 years and 24,000 years, respectively.

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Only small amounts of plutonium occur naturally. However, large amounts have been produced by man in nuclear reactors. Most environmental plutonium exists as oxides and nitrates. Measurable amounts of plutonium were released to the environment by atmospheric testing of nuclear weapons and by accidents at weapons production, and utilization facilities. In addition, accidents involving weapons transport, satellite re-entry, and the Chernobyl reactor fire have also released smaller amounts of plutonium to the atmosphere. The average levels in U. S. soils, from all sources are currently about 2 mCi/Km².

E.4.3.67.1 Pharmacokinetics

Absorption of plutonium from the gastro- intestinal tract is minimal following an oral ingestion. It is dependent on age, chemical form, stomach content, dietary intake, oxidation state, administration media, and other nutritional factors. A rapid decrease in absorption was seen with increasing age. In hamsters between 1 day and 30 days of age, absorption of plutonium decreased from 3.5 to 0.003 percent of the administered dose (ATSDR 1990b). In humans, the fraction of plutonium absorbed from the gastrointestinal tract into the blood (F_1) is 0.001 for highly soluble plutonium compounds and 1×10^{-5} for highly insoluble compounds. However, the most likely pathway of human exposure to plutonium is by inhalation. Once inhaled, the amount of plutonium which is retained by the lungs is dependent on several factors, such as the particle size and the chemical form of plutonium. The fraction of the highly soluble compounds which transfer from the lungs to the blood is 0.001 for Class W, and 1×10^{-5} for Class Y compounds. The ICRP task group concluded that no plutonium compounds should be assigned to inhalation Class D. Studies have indicated that plutonium is a lung, skeletal, and liver carcinogen in animals depending on its chemical form, route of exposure, and species. Plutonium-239 dioxide is insoluble, therefore, it is primarily retained by the lung and associated lymph nodes after inhalation. Soluble Pu-238 is translocated from the lung to the bone and liver.

E.4.3.67.2 Noncancer Toxicity

Radiation pneumonitis, characterized by alveolar edema, fibrosis, and pulmonary hyperplasia and metaplasia were observed in dogs, mice, rats, hamster, and baboons following high levels of inhalation exposure to Pu-239 or Pu-238 dioxide. Increases in liver enzymes were also observed after a single inhalation exposure to Pu-239 nitrate which resulted in 4.4×10^5 pCi/kg. Osseous atrophy and radiation osteodystrophy were observed 4,000 days post-exposure in dogs given a single inhalation exposure to Pu-238 dioxide.

Gastrointestinal effects were observed in neonatal rats following administration by gavage of 1×10^5 pCi/kg or 3.3×10^8 pCi/kg of Pu-239 citrate. In the lower dose group, mild hypertrophy of crypts of small intestines, which form the secretion of the small intestines, was observed 11 days post-exposure. Total disappearance of epithelial cells and crypts, combined with intestinal hemorrhaging, was observed in the higher dose group.

No studies were located regarding gastrointestinal, cardiovascular, renal, or dermal effects in humans or animals after inhalation exposure to plutonium. Similarly, no studies regarding respiratory, cardiovascular, hematological, musculoskeletal, hepatic, renal, or dermal effects in humans or animals after oral exposure to plutonium were located.

E.4.3.67.3 Carcinogenicity

Experiments in dogs have provided the most data on radiation-induced cancer following inhalation exposure to plutonium. The most frequently observed cancer in dogs treated with Pu-239 dioxide was lung cancer. The majority of lung tumors in dogs were broncholar-alveolar carcinoma. When dogs are treated with a more soluble form of Pu-239 or with Pu-238, plutonium translocates from the lungs to other sites, where liver and bone tumors, in addition to lung tumors, have been reported. However, lung tumors were the primary cause of death in dogs exposed to Pu-239 dioxide at an initial lung deposition as low as 2.1×10^4 pCi/kg. On the other hand, osteosarcomas was the primary cause of cancer death upon exposure to Pu-239 dioxide. Statistically significant increases in lung cancer have been reported in rats with lung deposition levels of 3.1×10^4 pCi of Pu-238 per kg body weight.

E.4.3.68 Polyaromatic Hydrocarbons

PAHs are a large class of ubiquitous natural and anthropogenic chemicals, all with similar chemical structures (ATSDR 1990). There are 16 individual PAHs listed among the CPCs for Operable Unit 1.

E.4.3.68.1 Pharmacokinetics

Although quantitative absorption data for the PAHs were not located, benzo(a)pyrene was readily absorbed across the GI (Rees et al. 1971) and respiratory epithelia (Kotin et al. 1969; Vainich et al. 1976). The high lipophilicity of other compounds in this class suggests that other PAHs also would be readily absorbed across GI and respiratory epithelia.

Benzo(a)pyrene was distributed widely in the tissues of treated rats and mice, but primarily to tissues high in fat, such as adipose tissue and mammary gland (Kotin et al. 1969; Schleder et al. 1970a). Patterns of tissue distribution of other PAHs would be expected to be similar because of the high lipophilicity of the members of this class.

Studies of the metabolism of benzo(a)pyrene provide information relevant to other PAHs because of the structural similarities of all members of the class. Metabolism involves microsomal mixed function oxidase hydroxylation of one or more of the phenyl rings with the formation of phenols and dihydrodiols, probably via formation of arene oxide intermediates (EPA 1979a). The dihydrodiols may be further oxidized to diol epoxides, which, for certain members of the class, are known to be the ultimate carcinogens (LaVoie et al. 1982). Conjugation with glutathione or glucuronic acid, and reduction to tetrahydrotetraols are important detoxification pathways. Metabolism of naphthalene

resulted in the formation of 1,2-naphthoquinone, which induced cataract formation and retinal damage in rats and rabbits.

Excretion of benzo(a)pyrene or dibenzo(a,h)anthracene residues was reported to be rapid, although quantitative data were not located (EPA 1979b). Excretion occurred mainly via the feces, probably largely due to biliary secretion (Schlede et al. 1970a, 1970b). The EPA (1980a) concluded that accumulation in the body tissues of PAHs from chronic low level exposure would be unlikely.

E.4.3.68.2 Noncancer Toxicity

Of the PAHs of concern, oral noncancer toxicity data are available for acenaphthene, anthracene, fluoranthene, fluorene, and naphthalene. Newborn infants, children, and adults exposed to naphthalene by ingestion, inhalation, or possibly by skin contact developed hemolytic anemia with associated jaundice and occasionally renal disease (EPA 1979c). In a 13-week gavage study in rats, treatment with 50 mg naphthalene/kg, 5 days/week for 13 weeks (35.7 mg/kg/day) induced no effects; higher doses presumably reduced the growth rate (National Toxicology Program (NTP) 1980). Application of an uncertainty factor of 1000 yielded a provisional RfD for chronic oral exposure of 0.04 mg/kg/day (EPA 1992b). The very mild effect (decreased growth rate) apparently observed at higher doses suggests that the RfD is very conservatively protective.

Acenaphthene appears to be a mild hepatotoxicant, and possibly a nephrotoxicant, in rodents (EPA 1993a). In a comprehensive 90-day toxicity study in mice, gavage treatment with 175 mg/kg/day was an NOAEL; liver weight changes accompanied by hepatocellular hypertrophy and elevated cholesterol levels occurred in mice treated with 350 or 700 mg/kg/day (EPA 1989e). Oral treatment of rats and mice for 32 days with 2000 mg/kg/day resulted in weight loss and mild liver and kidney lesions (Knobloch et al. 1969). The EPA (1993a) verified a chronic oral RfD for acenaphthene of 0.06 mg/kg/day based on an NOAEL for liver effects in a subchronic gavage study in mice and an uncertainty factor of 3000. An uncertainty factor of 3000 was used with factors of 10 each for inter- and intraspecies variation and to expand from subchronic to chronic exposure, and a factor of 3 to reflect gaps in the database, namely lack of adequate data in a second species and lack of developmental and reproductive data. Confidence in the database was low because of the data gaps. Confidence in the critical study was low because the effects were considered adaptive, rather than adverse, which implies that the RfD is extremely conservative. The EPA (1992b) presented a provisional subchronic oral RfD of 0.6 based on the same NOAEL and an uncertainty factor of 300. Target organs for acenaphthene include the liver and kidney.

The toxic potency of anthracene appears to be very low. In a chronic study in rats, doses of 5 to 15 mg/rat (16 to 48 mg/kg/day) via the diet had no effect on longevity or gross or histopathologic appearance on unspecified tissues (Schmahl 1955). Gavage treatment of mice with 1000 mg/kg/day for at least 90 days had no effects on a comprehensive range of toxicologic parameters (EPA 1989f).

The NOEL of 1000 mg/kg/day in mice and an uncertainty factor of 3000 (10 each for inter- and intraspecies variation, and 30 for the use of a subchronic study and an incomplete database) yielded a verified RfD for chronic oral exposure of 0.3 mg/kg/day (EPA 1993a). The EPA (1992b) presented a provisional subchronic oral RfD of 3 mg/kg/day based on the same NOEL and an uncertainty factor of 300. The data were inadequate to define target organs for the toxicity of anthracene.

Fluoranthene appears to be toxic to the liver, kidney, and blood. In a comprehensive 13-week gavage study in mice, 125 mg/kg/day was an NOAEL and 250 mg/kg/day was an LOAEL (EPA 1988c). The verified chronic oral RfD for fluoranthene is 0.04 mg/kg/day, based on the NOAEL in a comprehensive 13-week gavage study of 125 mg/kg/day in mice and an uncertainty factor of 3000 (EPA 1993a). The uncertainty factor of 3000 includes factors of 10 each for inter- and intraspecies variation, and a factor of 30 to expand from subchronic to chronic exposure and to reflect an incomplete database. A provisional subchronic oral RfD of 0.4 mg/kg/day was derived from the same NOAEL and an uncertainty factor of 300. The liver, kidney, and blood appear to be the target organs for the toxicity of fluoranthene.

The critical effects of oral exposure to fluorene appear to be hemolytic anemia and CNS effects. In mice treated by gavage for 13 weeks, 125 mg/kg/day was an NOAEL and 250 mg/kg/day was an LOAEL (EPA 1989g). A verified chronic oral RfD for fluorene of 0.04 mg/kg/day was based on the NOAEL of 125 mg/kg/day for hemolytic anemia in mice (EPA 1993a). An uncertainty factor of 3000 was used with factors of 10 each for inter- and intraspecies variation and to expand from subchronic to chronic exposure, and a factor of 3 to reflect gaps in the database. The EPA (1992b) presented a provisional subchronic oral RfD of 0.4 mg/kg/day based on the same NOAEL and an uncertainty factor of 300. The target organs of fluorene toxicity are the erythrocyte and the CNS.

Newborn infants, children, and adults exposed to naphthalene by ingestion, inhalation, or possibly by skin contact developed hemolytic anemia with jaundice and, occasionally, renal disease (EPA 1980a). In a 13-week gavage study in rats, treatment with naphthalene reduced the growth rate (EPA 1992b). Application of an uncertainty factor of 1000 to the rat NOEL yielded a provisional RfD for subchronic and chronic oral exposure of 0.04 mg/kg/day (EPA 1992b). The erythrocyte and the kidney appear to be the target organs for the toxicity of naphthalene.

Mild kidney lesions appear to be the critical effects of pyrene. In mice treated by gavage for 13 weeks, 75 mg/kg/day was an NOAEL and 125 mg/kg/day was an LOAEL (EPA 1989h). Even in mice treated with 250 mg/kg/day the lesions were considered minimal to mild. The EPA (1993a) verified a chronic oral RfD for pyrene of 0.03 mg/kg/day based on the NOAEL in mice and an uncertainty factor of 3000 (10 each for inter- and intraspecies variation and to expand from subchronic to chronic exposure, and a factor of 3 to reflect gaps in the database). The EPA (1992b) presented a

provisional subchronic oral RfD of 0.3 mg/kg/day based on the same NOAEL and an uncertainty factor of 300. The kidney is the target organ for the toxicity of pyrene.

E.4.3.68.3 Carcinogenicity

The PAHs are ubiquitous, being released to the environment from anthropogenic as well as from natural sources (ATSDR 1987). Benzo(a)pyrene is the most extensively studied member of the class, inducing tumors in multiple tissues of virtually all laboratory species tested by all routes of exposure. Although epidemiology studies suggested that complex mixtures that contain PAHs (coal tar, soots, coke oven emissions, cigarette smoke) are carcinogenic to humans (EPA 1993a), the carcinogenicity cannot be attributed to PAHs alone because of the presence of other potentially carcinogenic substances in these mixtures (ATSDR 1987). In addition, recent investigations showed that the PAH fraction of roofing tar, cigarette smoke, and coke oven emissions accounted for only 0.1 to 8 percent of the total mutagenic activity of the unfractionated complex mixture in Salmonella (Lewtas 1988). Aromatic amines, nitrogen heterocyclic compounds, highly oxygenated quinones, diones, and nitrooxygenated compounds, none of which would be expected to arise from in vivo metabolism of PAHs, probably accounted for the majority of the mutagenicity of coke oven emissions and cigarette smoke. Furthermore, coal tar, which contains a mixture of many PAHs, has a long history of use in the clinical treatment of a variety of skin disorders in humans (ATSDR 1987).

Because of the lack of human cancer data, assignment of individual PAHs to EPA cancer weight-of-evidence groups was based largely on the results of animal studies with large doses of purified compound (EPA 1993a). Frequently, unnatural routes of exposure, including implants of the test chemical in beeswax and trioctanoin in the lungs of female Osborne-Mendel rats, intratracheal instillation, and subcutaneous or intraperitoneal injection, were used. Of the PAHs of concern, no EPA cancer weight-of-evidence group classification was provided for acenaphthene (EPA 1993a). Anthracene, benzo(g,h,i)perylene, fluoranthene, fluorene, and naphthalene were classified in Group D (not classifiable as to carcinogenicity to humans), and benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene were classified in Group B2 (probable human carcinogens).

The EPA (1993a) verified a slope factor for oral exposure to benzo(a)pyrene of 7.3 per mg/kg/day, based on several dietary studies in mice and rats. Neither verified nor provisional quantitative risk estimates were available for the other PAHs in Group B2. The EPA (1980a) promulgated an ambient water quality criterion for "total carcinogenic PAHs," based on an oral slope factor derived from a study with benzo(a)pyrene, as being sufficiently protective for the class. Largely because of this precedent, the quantitative risk estimates for benzo(a)pyrene were adopted for the other carcinogenic PAHs when quantitative estimates were needed.

Recent reevaluations of the carcinogenicity and mutagenicity of the Group B2 PAHs suggest that there are large differences between individual PAHs in cancer potency (Krewski et al., 1989). Based on the available cancer and mutagenicity data, and assuming that there is a constant relative potency between different carcinogens across different bioassay systems and that the PAHs under consideration have similar dose-response curves, Thorslund and Chamley (1988) derived relative potency values for several PAHs. A more recent Toxicity Equivalency Function (TEF) scheme for the Group B2 PAHs was based only on the induction of lung epidermoid carcinomas in female Osborne-Mendel rats in the lung-implantation experiments (Clement International 1990). The most defensible TEFs and the associated oral and inhalation slope factors are presented in Table E.4-4.

E.4.3.69 Polychlorinated Biphenyls

E.4.3.69.1 Noncancer Toxicity

Epidemiologic studies of women in the United States associated oral PCB exposure with low birth weight or retarded musculoskeletal or neurobehavioral development of their infants (ATSDR 1991). Oral studies in animals established the liver as the target organ in all species, and the thyroid as an additional target organ in the rat. Effects observed in monkeys included gastritis, anemia, chloracne-like dermatitis, and immunosuppression. Oral treatment of animals induced developmental effects, including retarded neurobehavioral and learning development in monkeys. Neither subchronic nor chronic oral RfD values were located for any of the aroclors.

Occupational exposure to PCBs was associated with upper respiratory tract and ocular irritation, loss of appetite, liver enlargement, increased serum concentrations of liver enzymes, skin irritation, rashes and chloracne, and, in heavily exposed female workers, decreased birth weight of their infants (ATSDR 1991). Concurrent exposure to other chemicals confounded the interpretation of the occupational exposure studies. Laboratory animals exposed by inhalation to Aroclor-1254 vapors exhibited moderate liver degeneration, decreased body weight gain and slight renal tubular degeneration. Neither subchronic nor chronic inhalation RfC values were available.

Target organs for PCBs include the skin, liver, fetus, and neonate.

E.4.3.69.2 Carcinogenicity

The EPA (1993a) classifies the PCBs as EPA cancer weight-of-evidence Group B2 substances (probable human carcinogens), based on inadequate data in humans and sufficient data in animals. The human data consist of several epidemiologic occupational and accidental oral exposure studies with serious limitations, including poorly quantified concentrations of PCBs and durations of exposure, and probable exposures to other potential carcinogens.

The animal data consist of several oral studies in rats and mice with various aroclors, kanexchors, or clophens (commercial PCB mixtures manufactured in the United States, Japan and Germany, respectively) that reported increased incidence of liver tumors in both species (EPA 1993a).

The EPA (1993a) presents a verified oral slope factor of 7.7 per mg/kg/day for all PCBs based on liver tumors in rats treated with Aroclor-1260.

E.4.3.70 2-Propanol (Isopropyl Alcohol)

E.4.3.70.1 Noncancer Toxicity

Inhalation exposure of laboratory animals to high concentrations of 2-propanol induced narcosis (ACGIH 1986). Humans exposed to more moderate levels experienced mild irritation of the ocular and respiratory tract epithelia. Neither oral nor inhalation RfD or RfC values were located for 2-propanol. The principal target organ appears to be the CNS.

E.4.3.70.2 Carcinogenicity

There are no data implicating 2-propanol as a carcinogen (ACGIH 1986).

E.4.3.71 Radium

E.4.3.71.1 Noncancer Toxicity

No toxic effects of exposure to radium are documented and EPA has not developed an RfD for radium; therefore, the health hazard for radium is associated with potential radiocarcinogenic effects.

E.4.3.71.2 Carcinogenicity

Four isotopes of radium occur naturally, Ra-223 (actinium series), Ra-224 and Ra-228 (thorium series), Ra-226 (uranium series); therefore, radium is ubiquitous in the earth's crust and common in groundwater, mineral deposits, soil, food products, and common building materials. Ra-226 has the longest half-life (1600 years) and decays by alpha particle emission. Ra-223 and Ra-224 are also alpha-particle emitters, and Ra-228 is a beta-particle emitter. The primary uses of radium have been for manufacturing luminous dials and instrument faces and for internal radiation therapy. Thus, the bulk of the human data on effects from intake of radium are available from studies of radium dial painters and medical patients administered therapeutic doses of radium.

Radium introduced into the body generates decay products including gaseous isotopes of radon. Rn-222 generated in the body persists long enough that it easily diffuses into the bloodstream and accumulates in the sinuses of the head, significantly reducing the alpha dose to the radium accumulating tissues but increasing the dose in the sinus regions of the body. Ultimately the bone tissues are the principal site of radium accumulation because of the similar chemical behavior of

radium compared to calcium (National Academy of Sciences [NAS] 1988). In the bone tissues the radium is initially deposited in endosteal bone surface tissue. There is then a redistribution to the bone volume where the radium resides with a long retention time.

Dose Response Data - Human and Animal

The following discussion of data concerning the health effects of exposure to radium is summarized from the report of the Biological Effects of Ionizing Radiation (BEIR) IV Committee on radon and other alpha emitters (NAS 1988). The epidemiological studies of humans were initially motivated by the appearance of cancer and other effects associated with occupational exposures to Ra-224, Ra-226, and Ra-228 (radium dial painters). In the dial painting context, there was the potential to ingest significant quantities of radium that were known to be harmful. The second most significant study group comprised the ankylosing spondylitis patients, who were administered doses of radium solutions for therapeutic reasons. The focus of most studies is on bone cancer, cancer of the paranasal sinuses, and cancer of the mastoid air cells because the association of these effects with radium exposure is well known.

Although epidemiological investigations have documented the association between radium exposure and carcinogenic effects, there has been considerable debate over the dose-response relationship involved. Bone cancer incidence has been plotted against a variety of parameters that represent a measure of radium exposure such as absorbed dose to the skeleton, pure radium equivalents, and cumulative rad-years (Evans 1966). The results indicate a nonlinear relationship fits the data. A separate analysis of the same bone cancer induction data confirms the finding of a nonlinear fit (Mays and Lloyd 1972). The conclusion from both of these analyses is that a linear nonthreshold relationship is likely to significantly overpredict cancer incidence at low doses. Later reassessments present a linear-quadratic-exponential dose-response relationship (Rowland et al. 1971, 1978a, 1978b, 1983) and a dependence of incidence on the square of radium intake normalized to body weight (Marshall and Groer 1977).

Two extensive studies of ankylosing spondylitis patients treated in Germany with solutions of Ra-224 are most noteworthy. In the first, a 900-patient cohort treated with a Ra-224 colloid during the period from 1946 to 1951 with a follow-up period for more than 30 years revealed bone cancer incidence associated with the high absorbed doses from the therapeutic treatments (Spiess 1969; Spiess and Mays 1970, 1973). In the second, a cohort of about 1400 patients treated with small doses of Ra-224 for ankylosing spondylitis showed a similar association between dose and cancer induction (Spiess 1969; Spiess and Mays 1970; Mays 1973). The analyses are consistent with a variety of dose-response relationships; however, none could be disproved because of the scatter in the data.

Cancers of the paranasal sinuses and the mastoid air cells have been associated with exposure to Ra-226 and Ra-228 since the 1930s (Martland 1939). These effects were initially seen in the radium

183

dial painters, who received high absorbed doses from the quantities of radium they ingested. Excess incidence is quite evident in comparison to the natural incidence, which is very low. After exposure to radium, these types of cancers are expressed later than bone cancers (Evans et al. 1969; Finkel et al. 1969; Rowland et al. 1971; Rundo et al. 1986).

As discussed previously, Rn-222 generated in the body persists long enough that it easily diffuses into the bloodstream and accumulates in the sinuses of the head, significantly increasing the dose in the sinus regions of the body. Studies of cancers of the sinuses and mastoid cells conducted in beagle dogs injected with a variety of alpha-emitting radionuclides reveal excess incidence of these cancers (Schlenker 1980). Not all of the tumors were induced by alpha emitters that produce a gaseous decay product; therefore, a gaseous decay product is not essential to induction. Nevertheless, the risk of these cancers from Ra-226 and its decay products (including Rn-222) is considered significantly greater than from other alpha-emitting radionuclides.

The incidence of leukemia and other blood diseases is linked to radium ingested among the radium dial painters. Development of anemias and leukopenia (low leukocyte count) has been demonstrated in the dial painters (Martland 1931). Evans' study (Evans 1966) included leukemia and anemia as possible effects of radium accumulation in the body. Finkel (Finkel et al. 1969) found cases of leukemia and aplastic anemia in studies of the radium dial painters exposed during the period from 1918 to 1933. Among a cohort of 634 female dial painters first employed before 1930, three deaths attributable to leukemia were found (Polednak 1978). This exceeds expectations because the natural incidence of leukemia is very low. An epidemiological study of 1285 women employed as dial painters before 1930 and 1185 employed between 1930 and 1949 (when radium contamination and exposures were much lower) revealed standard mortality ratios of 73 and 221, respectively (Stebbins et al. 1984). However, the most comprehensive and definitive study of U.S. dial painters includes all workers employed before 1970 (Spiers et al. 1983). Among the worker cohort of 2940 persons, 10 cases of leukemia were found. The expected number of natural cases for this group would be 9.2 cases. The study concludes that the incidence in the cohort does not differ significantly from natural incidence (Spiers et al. 1983). In summary, the accumulation of very high levels of radium is associated with severe anemias and leukemia (NAS 1988). However, at lower levels of accumulation, such as those experienced by the majority of U.S. radium dial painters, especially in later years, the accumulated radium does not appear to significantly increase the risk of leukemia (NAS 1988).

The BEIR IV Committee presents a cancer risk factor of $200E-06$ per rad for bone sarcomas from protracted exposure to radium in its report on radon and other alpha emitters (NAS 1988).

0609

E.4.3.72 Radon and Progeny

E.4.3.72.1 Noncancer Toxicity

There are no known toxic effects of exposure to radon gas or its short-lived progeny. However, short-lived radon progeny decay to long-lived lead (Pb) progeny. Because lead is a chemical toxicant, significant accumulations of lead would pose a potential source of lead for exposure pathways to receptors.

E.4.3.72.2 Carcinogenicity

Exposure to air contaminated with radon gas and associated airborne progeny has been linked to increased risk of lung cancer. The risk is attributed to inhalation of the short-lived progeny of radon that are attached to particulates, which lodge in the lung passages and produce a radiation dose that causes lung cancer. Radon progeny that do not lodge in the lung passages are exhaled, and do not deliver a radiation dose. The induction of lung cancer results when the bronchial epithelium of the lung passages is exposed to alpha particles emitted from decaying radon progeny (e.g., Po-214 and Po-218) lodged in the lung passages.

Three isotopes of radon are of potential concern, one associated with each of the three natural decay series. Rn-222, Rn-220, and Rn-219 are members of the uranium, thorium, and actinium decay series, respectively. Rn-222 (half-life 3.82 days) is the isotope of primary concern because its half-life and mobility as an inert gas facilitate its migration to outdoor and indoor areas, thus potentially exposing receptors to elevated concentrations of Rn-222 and its short-lived progeny. Rn-220 (half-life 55.6 seconds) and Rn-219 (half-life 3.96 seconds) are generally of less concern because their very short half-lives often result in decay before there is sufficient opportunity for migration of the gas and accumulation of elevated quantities where receptors may be exposed. For example, all three isotopes of radon may be of concern in air in buildings that contain the appropriate parent radionuclides (in the form of surface contamination or drummed material for example). However, Rn-220 and Rn-219 are not expected to be released from a source such as the K-65 silos because their shorter half-lives would cause them to decay before migrating out of the waste matrix or out of the containment provided by the silos.

Dose Response Data - Human and Animal

The following discussion regarding the health effects of exposure to radon and radon progeny is summarized from the report of the BEIR IV Committee on radon and other alpha emitters (NAS 1988). The radiological effect of concern from exposure is lung cancer.

The lung cancer hazard associated with working in underground mines was first recognized by Harting and Hesse in 1879 as a result of autopsy studies of European miners (Harting and Hesse 1879). The most important human populations studied with regard to radon progeny exposure are the underground

0610

miners exposed to widely differing concentrations of airborne Rn-222 progeny in mines (National Council on Radiation Protection and Measurements [NCRP] 1984). The lung cancer mortality risk estimates for radon progeny exposure published by the BEIR IV Committee (NAS 1988) are based on an epidemiological study of these underground miner populations. The assessment of the risk from exposure to radon progeny by the BEIR IV Committee represents the most recent comprehensive examination of estimated health risks associated with exposure.

The BEIR IV Committee relies heavily on data from four principal studies of miners: Ontario uranium miners, Saskatchewan uranium miners, Swedish metal miners, and Colorado Plateau uranium miners. Underground miners exposed to radon progeny (in the mines) have an increased risk of lung cancer as demonstrated in these epidemiological study populations. Animals experimentally exposed to airborne radon progeny also develop lung cancers. Animal studies have provided information on the dose response relationship and the effects of variation in exposure rate, physical characteristics of the lung, and air quality to supplement the information available from the human epidemiological studies. Thus, both human epidemiological data and animal experimental data indicate that exposure to radon progeny induces lung cancer and describe the relationship between exposure and health effect as a function of influencing factors.

In its study of the human epidemiological data, the BEIR IV Committee has reevaluated the primary data (e.g., exposure histories and mortality) for the four principal epidemiological study groups of underground miners exposed to radon progeny. From this reevaluation, the BEIR IV Committee has developed estimates of the risk of fatal lung cancer. The BEIR IV lifetime risk estimate from lifetime exposure to radon progeny is $350\text{E-}06$ excess fatal lung cancers per cumulative working level month (WLM) exposure. The WLM is defined as cumulative exposure to an airborne concentration of short-lived radon progeny (equal to one working level) for a period of one working month. It must be noted that this estimate is quantified as fatal lung cancer risk, is based primarily on epidemiological studies of humans, and is expressed per unit cumulative exposure to progeny (WLM^{-1}). The EPA slope factors address cancer incidence, are based on calculated radiation doses to organs and tissues, and are expressed per unit radioactivity intake (pCi^{-1}). Thus, the EPA and BEIR IV risk estimates are not directly comparable. The EPA cancer slope factors are used for assessments of risk attributable to radon and radon progeny exposure. It is also noted that EPA adopted a nominal risk estimate of $360\text{E-}06$ per WLM for use in the National Emission Standards for Hazardous Air Pollutants (NESHAP) (EPA 1989a). This estimate is based primarily on EPA's consideration of the BEIR IV assessment; however, EPA did average radon risk estimates derived from BEIR IV and International Commission on Radiation Protection (ICRP) models to calculate the estimate of $360\text{E-}06$ per WLM.

Although the carcinogenicity of radon progeny is established and the hazards of exposure during mining are well recognized, the hazards of exposure in other environments have not yet been adequately quantified (NAS 1988). A few exploratory epidemiological studies of lung cancer risk

associated with radon progeny exposure in homes have been conducted; however, the results are inconclusive and inadequate for the purpose of risk estimation (NAS 1988).

The model developed by the BEIR IV Committee may be used to estimate risks under other environmental conditions to which persons may be routinely exposed; however, it must be recognized that the BEIR IV Committee's model is based on epidemiological evaluations of occupational exposure conditions in underground mines. Therefore, assumptions must be made regarding the similarity of exposed populations, levels of exposure, and factors such as cigarette smoking when using the model for nonoccupational conditions such as in indoor home environments and other environmental settings.

Using the risk factor from the BEIR IV report (NAS 1988) of $350\text{E-}06\text{ WLM}^{-1}$ for lung cancer mortality from inhalation of Rn-222 and progeny, and by assuming 51.5 working months (WM) per year (8760 hr/yr divided by 170 hrs worked/month), 100 pCi radon/liter air, short-lived Rn-222 progeny present in 50 percent equilibrium, and an inhalation rate of $20\text{ m}^3\text{ day}$ for 365 days/year, one can derive a lung cancer mortality risk factor of $1.2\text{E-}11$ per pCi. The EPA cancer slope factor from the HEAST publication for inhalation of Rn-222 plus progeny is $7.7\text{E-}12$ per pCi (EPA 1992b). It must be noted that the BEIR IV risk estimate pertains to lung cancer mortality while the EPA cancer slope factors all pertain to cancer induction rather than cancer fatality.

E.4.3.73 Selenium

E.4.3.73.1 Noncancer Toxicity

Selenium is a nutritionally essential trace element that is an integral part of the enzyme glutathione peroxidase and other proteins (Högberg and Alexander 1986). The National Research Council (1989) recommended dietary allowances (RDAs) for humans range from 10 to 75 $\mu\text{g/day}$. Chronic ingestion of 5 mg/day (0.071 mg/kg/day, assuming humans weigh 70 kg) induced selenosis in humans, characterized by abnormal hair and nail formation (Högberg and Alexander 1986). Effects in domestic grazing animals exposed to high levels of selenium included emaciation, lameness, and loss of hair and hooves. Occupational exposure to selenium fume or various selenium compounds was associated with intense ocular and respiratory tract irritation, chemical pneumonia, skin rashes, garlic odor to the breath, metallic taste in the mouth, and various socio-psychological effects (ACGIH 1986). The EPA (1993a) presented a verified RfD of 0.005 mg/kg/day for chronic oral exposure to selenourea, based on effects in humans exposed to selenium in high selenium areas. An uncertainty factor of 3 was used. The EPA (1992b) presented the same value as a provisional subchronic oral RfD. The principal target organs for oral exposure to selenium are the skin, including the nails and hair, and, in animals, the hooves and joints. Targets for inhalation or dermal exposure include the skin and mucous membranes of the eyes and respiratory tract, and possibly the CNS.

787

E.4.3.73.2 Carcinogenicity

An impressive body of data indicates that selenium exerts an anticarcinogenic effect (Högberg and Alexander 1986). In laboratory animals, selenium supplementation decreased the incidence of chemical-induced cancers. In humans, the incidence of lymphomas and cancers of the breast, digestive tract, and lung were lower in geographic areas with high soil selenium levels. Occupational data suggest that selenium may protect against lung cancer. Several animal tests with various deficiencies in design and conduct equivocally associated exposure to selenium with cancer induction. In a well controlled oral experiment, selenium sulfide was associated with an increase in the incidence of liver tumors in rats, and with liver and lung tumors in mice. On the basis of this study, EPA (1993a) classified selenium sulfide a cancer weight-of-evidence Group B2 compound (probable human carcinogen), but declined to derive quantitative risk estimates. Selenium and other selenium compounds were classified in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans) (EPA 1993a). Quantitative risk estimates are not derived for Group D substances.

E.4.3.74 Silver

E.4.3.74.1 Pharmacokinetics

The GI absorption of ingested silver in animals was estimated at ≤ 10 percent; however, absorption of 18 percent was estimated for one human subject given silver acetate (Fowler and Nordberg 1986). Highest tissue levels are located in the liver; lower levels are located in the lungs, brain, spleen, bone marrow, muscle, and skin (Fowler and Nordberg 1986; Goyer 1991). Excretion is virtually entirely through the bile. The excretion kinetics appear to be species- and organ-dependent. In humans, the apparent half-life for silver in the liver is approximately 50 days. Silver in skin also appeared to have a long half-life (not quantified).

E.4.3.74.2 Noncancer Toxicity

Silver compounds have been used in dentistry, medicinally in the treatment of burns, as a local disinfectant, and as a drinking water disinfectant (Fowler and Nordberg 1986). The classical syndrome of toxicity, called argyria, is a blue-gray to nearly black discoloration of areas of the skin or the viscera resulting from deposition of microscopic granules of silver compounds in the affected tissues. Argyria results from occupational (inhalation), parenteral, or oral exposure. The EPA (1993a) derived an RfD of 3 $\mu\text{g}/\text{kg}/\text{day}$ for chronic oral exposure, based on an LOAEL for argyria estimated at 5.2 $\mu\text{g}/\text{kg}/\text{day}$ in a person who ingested silver acetate as an anti-smoking aid for 2.5 years (East et al. 1980). Data from other cases of argyria involving medicinal (oral and intravenous) treatment were considered in this evaluation. An uncertainty factor of two was applied because the critical effect is considered to be only minimally severe.

E.4.3.74.3 Carcinogenicity

The EPA (1993a) classifies silver in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans). The human data consist of no evidence in the literature of cancer despite frequent medical use of silver compounds. The animal data are limited to studies of implanted silver foil or injected metallic silver that provided unconvincing indications of a carcinogenic response relevant to humans.

E.4.3.75 Strontium

Strontium is a naturally-occurring element that is very similar to calcium in structure. Strontium-90 (Sr-90) is one of the most common radioisotopes of strontium. Sr-90 is a pure beta-particle emitter that is in equilibrium with its decay product, yttrium-90, also a beta-particle emitter. The half-life of Sr-90 is approximately 29 years. Sr-90 is a product of nuclear fission. Much of the Sr-90 in the environment is a result of fallout from atmospheric testing of nuclear weapons. The estimated global inventory of Sr-90 (as a result of fallout) at the end of 1980 was approximately 1E07 Ci (United National Scientific Committee on the Effects of Atomic Radiation [UNSCEAR] 1982). Since the mid-1970s nuclear power reactors and fuel reprocessing plants have produced a large inventory of Sr-90 as a result of their operations and waste generation (NCRP 1991). Because of the potential for accidents, this source of Sr-90 has become of greater concern than fallout from atmospheric testing. Sr-90 sources have been used in medical therapy, polymerization of plastic, synthesis of organic compounds, and sterilization of surgical and medical supplies (Menhinick 1966).

E.4.3.75.1 Pharmacokinetics

Because of strontium's chemical similarity to calcium, the ultimate site of accumulation is bone tissue. When strontium is taken into the body, an average of 30 percent is absorbed from the GI tract (NCRP 1991). The portion that is absorbed is distributed to either bone volume; plasma, extracellular fluid, soft-tissue, and bone surface; or is eliminated from the body. Early studies found that although strontium and calcium are chemically similar, biological systems do not use strontium as effectively as they do calcium, i.e., the systems discriminate between strontium and calcium.

E.4.3.75.2 Chemical Toxicity

Several papers were located in the literature which address the question of noncancer toxicity of strontium. Storey (1961) performed an experiment on young and adult rats. He fed young (40 to 60 g) and adult (200 to 250 g) female rats diets with varying strontium levels. For young rats, the strontium doses corresponded to 190, 380, 750, 1000, 1500, and 3000 mg/kg/day, and for adult rats 95, 190, 375, 750, and 1500 mg/kg/day. Young rats were found to be affected more severely at lower dietary strontium levels than were adult rats. In young rats, at 380 mg/kg/day, the epiphyseal plate was irregular and slightly widened; however, at 750 mg/kg/day, this plate was severely irregular. Changes observed with doses at 380 mg/kg/day and higher were inhibition of calcification, as evidenced by increasing width of epiphyseal cartilage, presence of uncalcified bone matrix, and

decreased ash weight of bone. In adults rats, the first obvious bone change occurred at the 750 mg/kg/day dose level and included slightly wider than normal epiphyseal cartilage plate that was irregularly increased in length and width. Based on these results, an NOAEL of 190 mg/kg/day and an LOAEL of 380 mg/kg/day were identified for young rats. For adult rats, an NOAEL of 375 mg/kg/day and an LOAEL of 750 mg/kg/day were given.

Marie et. al. (1985) administered stable strontium to male rats. The purpose of the study was to determine the effect of low doses of stable strontium on mineral homeostasis and bone histology. The authors concluded that an oral dose lower than 633 mg/kg-day did not produce adverse effects on body growth or bone mineralization. Rats with a dose of 633 mg/kg-day showed signs of increased mineralization lag time; excessive osteoid thickness associated with a decline in the rate of calcification, which resulted in slow growth rate; and a decreased double-labeled osteoid surface, which resulted in defective long bone growth. This study identified an NOAEL of 525 mg/kg/day and an LOAEL of 633 mg/kg/day.

Pertinent data to derive an oral RfD based on the toxicity of stable strontium in humans were not located in the available literature.

E.4.3.75.3 Carcinogenicity

NCRP Report No. 110 (1991) cites a number of papers that address the radiocarcinogenicity of strontium. These papers were published by different authors and the experiments were conducted in different laboratories on different animals such as mice, rats, cats, dogs, and monkeys. The experiments have shown that high radiation doses to skeletal tissues from radioactive strontium (Sr-90 or Sr-89) would produce bone sarcomas, carcinomas of the nasopharynx and head sinuses, squamous cell carcinomas in tissues within the mouth, or hematopoietic neoplasia (leukemia) and dysplasia.

There is clear evidence in these experiments that the dosage pattern, the total dose, and the age at irradiation can have a significant effect on the outcome of exposure. However, lower doses of radiation from Sr-90 produced a very low incidence, or not at all, from this radionuclide (i.e., no bone sarcomas were seen at individual average skeletal doses in a study conducted on dogs with doses between 1 and 18 Gray (Gy).

There have been no cases of human exposure to Sr-90 on record which would provide direct guidance concerning the kinds of effects to be expected or their frequency. Attempts to study effects due to Sr-90 present in fallout were beset by two difficulties: (1) No criteria were known that would distinguish unambiguously the pathological effects due to Sr-90 from those occurring naturally, (2) The excess of incidence to be expected at world-wide fallout levels was so low that only studies on very large populations could even potentially yield a statistically significant result. Such studies have been attempted for humans, but careful evaluation of the statistics confirms the expectation that

whatever excess of incidence may be present is masked by variation in incidence among the population groups studied, differences in recording data, and normal statistical fluctuations of the data for such groups. Thus, no statistically significant excess of biological effects due to Sr-90 exposure at levels characteristic of world-wide fallout has been demonstrated.

Lacking direct data on humans with Sr-90, one can attempt to estimate hazard on the basis of experience in man with other forms of radiation or on the basis of dose effect relations seen in experimental animals exposed to Sr-90. Thus, the observation that bone sarcomas have been produced in humans by skeletally-deposited radium and that leukemias have been produced by exposure to x-rays and atomic bomb radiation, suggest that significant skeletal doses from Sr-90 could produce bone sarcomas and leukemias in people.

E.4.3.76 Styrene

E.4.3.76.1 Noncancer Toxicity

Inhalation exposure of humans to styrene was associated with unspecified unpleasant symptoms and neurological impairment (ACGIH 1986). Subchronic oral exposure of animals induced liver and kidney lesions and hematologic and histopathologic evidence of hemolysis (EPA 1993a). The EPA (1993a) presented a verified chronic oral RfD of 0.2 mg/kg/day, based on an NOAEL for effects on erythrocytes and the liver in dogs and an uncertainty factor of 1000. The EPA (1992b) presented a provisional subchronic RfD of 2 mg/kg/day based on the same NOAEL and an uncertainty factor of 100. The EPA (1992b) also presented provisional inhalation RfC values of 1 mg/m³ for chronic exposure and 10 mg/m³ for subchronic exposure, based on an NOAEL for CNS effects in humans exposed for 8 hours. An uncertainty factor of 30 was used for derivation of the chronic RfC and an uncertainty factor of 10 was used for the subchronic RfC. The chronic and subchronic RfC values are equivalent to 0.3 mg/kg/day and 3 mg/kg/day, respectively, assuming humans inhale 20 m³ of air/day and weigh 70 kg. The principal target organs for inhalation exposure to styrene appear to be the CNS. Target organs for oral exposure include the liver, kidney, and erythrocyte.

E.4.3.76.2 Carcinogenicity

An appropriate cancer weight-of-evidence classification for styrene has not yet been decided by the EPA (1992h). Therefore, no classification and no quantitative estimates are presented.

E.4.3.77 Technetium

Technetium (Tc) is a radioactive element, with three isotopes having half-lives of more than 1 year. Tc-99 and Tc-96 isotopes are used in medicine and metallurgy. Tc-99 is a beta-emitting radionuclide that is produced with a high yield during the nuclear fission of U-235 and plutonium-239 (Pu-239). Of these, only Tc-99 is of potential concern in Operable Unit 1. It is quite mobile in the environment and tends to concentrate in the food chain.

E.4.3.77.1 Pharmacokinetics

The human effects data are primarily based on experimental results from volunteer subjects who received one dose of either Tc-99 or Tc-96 followed by 8 to 10 days of urine and fecal sampling as well as whole-body counting. It is found that the technetium accumulates in the bladder within 10 minutes after an injection. After two hours the technetium is localized primarily in the salivary-thyroid glands, stomach, liver, and bladder.

E.4.3.77.2 Noncancer Toxicity

Of the brief information available on the toxicity of Tc-99, it appears that it is quite toxic to plants. Gerber (1989) studied the toxic effects of Tc-99 on rats; he concluded that a critical organ could be the thyroid because of its preferential accumulation of technetium. He fed the rats diets containing 10 µg of Tc-99 per gram of food (10 µg/g) and 50 µg/g. It was found that thyroids, followed by kidneys, displayed the highest activities. Considerable amounts of technetium were also found in the liver, spleen, lung, and pancreas; the muscle and brain contained little technetium. The radiation dose administered to the thyroid after feeding 10 µg/g of Tc-99 for 13 weeks was estimated at 10 to 20 Gy. This dose was believed to be at the borderline where effects of radiation may be expected. Therefore, the question of chemical toxicity damage at higher doses of Tc-99 becomes more pronounced.

The authors concluded that in view of the large amounts of technetium to which the animals were exposed, it is unlikely that technetium could represent a significant nonstochastic risk to humans under any condition imaginable in the context of radiation protection. Earlier studies in rats (Van Bruwaene et al. 1986) have demonstrated that damage to the thyroid or reduction in fertility is detectable at a concentration of 10 µg of Tc-99 per gram of food, but not a concentration of 1 µg/g.

Coffey and Hayes have studied the radiation dosimetry and chemical toxicity of Tc-99. They injected mice via the tail vein with 210 to 360 mg of Na ⁹⁹Tc O₄ per kilogram of body weight, they found that the intravenous LD_{50/30} dose of Na ⁹⁹Tc O₄ in mice is 240 mg/kg. Earlier studies predicted that a given chemical dose may be about a factor of 10 more toxic in humans than in mice. This means that 24 mg/kg would be the extrapolated LD_{50/30} for Na ⁹⁹Tc O₄ in humans. Since LD_{50/30} is the lethal dose to 50 percent of a population in 30 days, it is of course not an acceptable risk for occupational or environmental exposures.

Probably no more than 1 percent of the LD_{50/30} dose would be an acceptable risk, i.e., 0.24 mg/kg. This is equal to 16.8 mg of Na ⁹⁹Tc O₄ in a 70-kg individual, or 151 µCi of Tc-99, which is less than 4 percent of the current annual limit intake (ALI) of 4000 µCi. The authors have concluded that the chemical toxicity of Tc-99 may be more important than its radiation risk in the event of accidental intake of Tc-99.

E.4.3.77.3 Carcinogenicity

Data on the carcinogenicity of technetium were not located in literature. Gerber (1989) studied the histology of rats fed with 10 and 50 µg/g of Tc-99. Of the 24 animals studied, one case of papillary adenoma was found after treatment with 10 µg/g Tc-99. This, of course, is insufficient to prove the carcinogenic effect of technetium, and therefore more research is needed to study the cancerous effects of technetium.

E.4.3.78 1,1,2,2-Tetrachloroethane (Tetrachloroethane)

E.4.3.78.1 Noncancer Toxicity

Chronic oral exposure of laboratory animals to 1,1,2,2-tetrachloroethane was associated with liver and kidney effects (ATSDR 1989g). Acute occupational exposure to high levels was associated with CNS effects; prolonged exposure to more moderate levels was associated with GI disturbances and liver damage (ACGIH 1986). Inhalation exposure studies in animals confirm that 1,1,2,2-tetrachloroethane is highly hepatotoxic. Neither oral nor inhalation RfD or RfC values were located. The target organs for 1,1,2,2-tetrachloroethane are the liver, kidney, and the CNS.

E.4.3.78.2 Carcinogenicity

Oral treatment with 1,1,2,2-tetrachloroethane induced a highly significant dose-related increase in hepatocellular carcinomas in rats (ATSDR 1989g). Occupational data regarding carcinogenicity in humans are inadequate. The EPA (1993a) classifies 1,1,2,2-tetrachloroethane as a cancer weight-of-evidence Group C compound (possible human carcinogen), based on liver tumors in mice, and derived an oral slope factor of 0.2 per mg/kg/day. The same data serve as the basis for an inhalation unit risk of 5.8E-05 per µg/m³, which is equivalent to 0.2 per mg/kg/day, assuming humans inhale 20 m³ of air/day and weigh 70 kg.

E.4.3.79 Tetrachloroethene (Tetrachloroethylene)

E.4.3.79.1 Noncancer Toxicity

Occupational (inhalation and dermal) exposure to tetrachloroethene was associated with neurologic effects, beginning with incoordination and progressing to dizziness, headache, vertigo, and unconsciousness (ACGIH 1986). The EPA (1993a) presented a verified chronic oral RfD for tetrachloroethene of 0.01 mg/kg/day based on an NOAEL for liver toxicity in mice in a subchronic gavage study, and on an NOEL for depressed body weight gain in rats in a subchronic drinking water study. An uncertainty factor of 1000 was used. The EPA (1992b) presented a provisional subchronic oral RfD of 0.1 mg/kg/day based on the same NOEL and an uncertainty factor of 100. The CNS is the principal target organ for inhalation exposure and the liver is the principal target organ for oral exposure to tetrachloroethene.

E.4.3.79.2 Carcinogenicity

Inhalation exposure to tetrachloroethene induced mononuclear cell leukemia in rats, and inhalation or oral exposure induced hepatocellular carcinomas in mice (ATSDR 1988b). Occupational exposure data do not suggest a carcinogenic role for tetrachloroethene in humans (ACGIH 1986). Interpretation of the data regarding the carcinogenicity of tetrachloroethene is controversial, and the EPA (1992h) has not adopted a final position on the cancer weight-of-evidence classification or quantitative risk estimates for tetrachloroethene. For this reason, the cancer evaluation of tetrachloroethene was removed from the 1992 HEAST (EPA 1992b). Currently, EPA believes the weight-of-evidence to be on the C-B2 continuum (possible-probable human carcinogen), and offers slope factors of 0.052 per mg/kg/day for oral exposure and 0.002 per mg/kg/day for inhalation exposure as being useful.

E.4.3.80 Thallium, Soluble Salts**E.4.3.80.1 Noncancer Toxicity**

Thallium is highly toxic; acute ingestion by humans or laboratory animals induced gastroenteritis, neurological dysfunction, and renal and liver damage (Kazantzis 1986). Chronic ingestion of more moderate doses characteristically caused alopecia. Thallium was used medicinally to induce alopecia in cases of ringworm of the scalp, sometimes with disastrous results. In industrial (inhalation, oral, dermal) exposure, neurologic signs preceded alopecia, suggesting that the nervous system is more sensitive than the hair follicle. The EPA (1993a) presented verified chronic oral RfD values for several thallium salts (thallium acetate, thallium carbonate, thallium chloride, thallium nitrate, and thallium sulfate) based on increased incidence of alopecia and increased serum levels of liver enzymes indicative of hepatocellular damage in rats treated with thallium sulfate for 90 days. An oral RfD for thallium alone, however, was not located. Target organs for thallium include the GI tract (acute exposure), nervous system, skin, kidney, and liver.

E.4.3.80.2 Carcinogenicity

Several thallium compounds (thallium oxide, thallium acetate, thallium carbonate, thallium chloride, thallium nitrate, thallium sulfate) were classified as cancer weight-of-evidence Group D substances (not classifiable as to carcinogenicity to humans) (EPA 1993a). No weight-of-evidence classification was located for thallium alone.

E.4.3.81 Thorium**E.4.3.81.1 Noncancer Toxicity**

No toxic effects of exposure to thorium are documented and EPA has not developed an RfD for thorium; therefore, the health hazard for thorium is associated with potential radiocarcinogenic effects.

E.4.3.82.2 Carcinogenicity

Natural thorium is present in the earth's crust as a primordial element. The Th-232 isotope accounts for approximately 100 percent of the mass abundance of thorium; however, the radioactivities of other isotopes of thorium exist as members of the three natural decay series. The half-life of Th-232 is very long (approximately 10^{10} years), thus the specific activity is relatively low and the rate of decay is slow. Th-232 decays by alpha particle emission as do most of the progeny in the thorium natural decay series.

Thorium has been used historically as a medical imaging agent because it is a heavy atom that provides contrast in radiographic imaging techniques. In this role thorium has been used commercially as Thorotrast, a 25 percent colloidal solution of thorium dioxide. Thorotrast has been used extensively in the U.S., Europe, and Japan as an intravascular contrast agent for cerebral and limb angiography. Thorotrast has also been injected into the spleen for hepatolienography and into nasal and paranasal sinuses. These uses of Thorotrast result in deposition of the thorium (and subsequent decay products) in tissues and organs of the body, most frequently in the reticuloendothelial tissues in bone (NAS 1988). Once deposited in these tissues, alpha particle emissions from the decay of Th-232 and its progeny irradiate the tissues for long periods of time at low dose rates. The following discussion of the study of health effects from exposure to thorium is summarized from the report of the BEIR IV Committee on radon and other alpha emitters (NAS 1988).

Dose Response Data - Human

The human data on health effects of exposure to thorium are primarily based on epidemiological studies of Thorotrast patients in five studies including German patients, Portuguese patients, Japanese patients, Danish patients, and American patients. In the study of German Thorotrast patients (van Kaick et al. 1978a, 1978b, 1983, 1984a, 1984b, 1986) 5159 patients and 5151 controls were followed from 1933 and 1935, respectively. The Thorotrast patients underwent intravascular injections of Thorotrast to enhance the imaging of cerebral and limb angiography. The results of the follow-up analysis indicate an excess of malignant cancers, most notably liver cancers and leukemias, among the patients relative to the controls.

The study of Portuguese Thorotrast patients (Abbatt 1973; da Motta et al. 1979; Horta et al. 1978) involves about 2500 patients and 2000 controls with a follow-up period of about 30 years. The patients were exposed to Thorotrast during the period from 1929 to 1955, with roughly 60 percent receiving Thorotrast doses for cerebral angiography. The results of the study show a significant excess of malignant cancer deaths among the patients compared to the control group. Particularly notable are the excess patient liver malignancies compared to the controls.

The study of Japanese Thorotrast patients (Kato et al. 1979, 1983; Mori et al. 1979a, 1979b, 1983, 1986) includes 282 patients who were administered Thorotrast for angiography and hepatolienography

during World War II. The follow-up period spans 38 to 46 years, and results reveal that patient mortality from malignant liver cancers, other malignant cancers, blood diseases, and cirrhosis of the liver is significantly higher than in the control group.

The study of Danish Thorotrast patients (Faber 1973, 1977, 1978, 1979, 1983, 1986) involves 1319 Danes injected with Thorotrast during the period from 1935 to 1946. The epidemiological analysis reveals excess GI malignancies, liver malignancies, malignancies of the lung, and leukemia deaths in patients compared to control individuals. The excess of liver malignancies and leukemias is most notable in the study.

The study of American Thorotrast patients (Falk et al. 1979) is a preliminary epidemiological assessment of Thorotrast patients exposed during the period from 1964 to 1976. All patients had received Thorotrast for either hepatolienography or cerebral angiography. A liver cancer incidence is evident in the investigation and is reportedly continuing to increase. Further follow-up of these individuals is needed.

All five of these human epidemiological studies indicate an excess of malignant cancers among the Thorotrast patients compared to the controls. The excess malignancies are predominantly of the liver and blood (leukemia) types.

Estimation of Excess Risk from Thorotrast Administration

The human epidemiological evidence from studies of the Thorotrast patients represents the primary source of data from which an estimate of risk can be derived (NAS 1988). These data can be used to derive estimates of risk for liver cancer and leukemia; however, such estimates would only strictly apply to conditions of intravascular Thorotrast injection. The BEIR IV report derives a risk estimate of up to $300\text{E-}06$ per rad of alpha particle radiation to the liver, and emphasizes that these estimates are for Thorotrast, not thorium. The emphasis is because the dosimetry of other isotopes of thorium will differ from that of the Th-232 in the Thorotrast colloid form. The BEIR IV report also derives a risk estimate of up to $60\text{E-}06$ per rad of alpha radiation to bone marrow for leukemia, and a value of up to $120\text{E-}06$ per rad alpha radiation to the skeleton without marrow for bone cancer (NAS 1988).

Dose Response Data - Animal

Experimental studies of animals administered modified Thorotrast solutions have provided insight concerning the possible influence on carcinogenicity of Thorotrast in humans from a "foreign body effect" (from the colloid solution), or a toxicological effect of the thorium in addition to a radiation dose effect. Studies in mice have been performed using Thorotrast solutions fortified with Th-230 to increase the specific activity of alpha emissions delivering radiation dose to tissues, conventional Thorotrast, and zirconium dioxide solution (Zirconotrast). There was no evidence of increased carcinogenicity of Thorotrast relative to Zirconotrast (Bensted 1967). Rabbits injected with Th-230

enriched Thorotrast revealed a shortened latency period (Faber 1973) associated with the higher specific activity solution. The metabolic distribution of Thorotrast and other colloid solutions has been examined in mice, rabbits, rats, and dogs including zirconium and hafnium dioxide colloids. The organ distribution of the Thorotrast and associated progeny in these animals was found to be comparable to that in humans (Riedel et al. 1979, 1983). The other colloids failed to reveal significantly different effects attributable to their distributions compared to the Thorotrast (Riedel et al. 1979, 1983).

A study of dose response and whether a foreign body effect occurs was conducted by administering different Th-230 enrichments of Thorotrast (causing variation in dose rate) and by administering different volumes of Thorotrast (dilutions maintaining constant dose rate) to rats (Wesch et al. 1973, 1983). Results of frequency of cancers followed a linear dependence with dose rate; however, variation of the volume of Thorotrast administered did not correlate with frequency of induction. Although cancer risk did not increase with volume of Thorotrast at a constant dose rate, the latent period was shortened (Wesch et al. 1973, 1983).

Additional studies in rats involved injection with Zirconotrast enriched with Th-228. Cancer induction in the animals was elevated and the cancers induced were similar to those induced in humans by Thorotrast (Wesch 1986). The frequency of cancer induction was dose rate dependent and the Zirconotrast without Th-228 did not induce excess cancers (Wesch 1986).

In summary, the animal experimental evidence indicates that Thorotrast induces cancers as a result of the radiation dose delivered by the solution. The physical presence of particles in the colloid solution and the chemical effect of the thorium are not likely to influence the induction of cancer (NAS 1988).

E.4.3.82 Inorganic Tin

E.4.3.82.1 Pharmacokinetics

Estimates of the gastrointestinal absorption efficiency of tin in humans and animals range from 0.6 percent to 5 percent (Magos 1986). The data suggest that tin in the +2 valence state is more readily absorbed than tin in the +4 valence state. Species differences in gastrointestinal absorption appear to be slight. Absorption efficiency appears to be somewhat greater when the administered dose is smaller. From these data, it appears that an estimate of 5 percent (0.05) is a reasonable estimate of gastrointestinal absorption efficiency. Data regarding dermal uptake of tin were not located.

E.4.3.82.2 Noncancer Toxicity

Industrial (inhalation) exposure to tin dust results in a benign pneumoconiosis called stannosis (Magos 1986). Acute oral exposure causes gastroenteritis (nausea and diarrhea) in humans. Other effects in animals include anemia, interference with calcium metabolism, and liver and kidney lesions. A

chronic oral RfD of 0.66 mg/kg-day was based on a NOAEL for liver and kidney lesions of 2000 ppm stannous chloride in the diet in a two-year study in rats (EPA 1992b). An uncertainty factor of 100 was applied. The chronic oral RfD was considered sufficiently protective for subchronic exposure as well.

E.4.3.82.3 Carcinogenicity

Data regarding the carcinogenicity of tin were not located in the available literature.

E.4.3.83 Toluene

E.4.3.83.1 Noncancer Toxicity

In a subchronic gavage study, high doses of toluene induced slight changes in liver and kidney weights in rats (EPA 1993a). Inhalation exposure of laboratory animals or humans was associated primarily with CNS depression (ATSDR 1989h). Recent developmental toxicity studies in animals suggest that the fetus or offspring may be unusually sensitive to effects on the developing nervous system. The EPA (1993a) presented a verified chronic oral RfD for toluene of 0.2 mg/kg/day based on a NOAEL for changes in liver and kidney weights in rats in a 13-week gavage study and an uncertainty factor of 1000. A provisional subchronic oral RfD of 2 mg/kg/day was based on the same NOAEL and an uncertainty factor of 100 (EPA 1992b). The EPA (1993a) presented a verified chronic inhalation RfC of 0.4 mg/m³ based on an LOAEL for neurological effects in occupationally exposed humans and an uncertainty factor of 300. The EPA (1992b) presented a provisional subchronic inhalation RfC of 2 mg/m³, based on a NOAEL for CNS effects and mucosal irritation in humans and an uncertainty factor of 100. The chronic inhalation RfC is equivalent to 0.1 mg/kg/day, assuming humans inhale 20 m³ of air/day and weigh 70 kg. Similarly estimated, the subchronic inhalation RfC is equivalent to 0.6 mg/kg/day.

E.4.3.83.2 Carcinogenicity

Toluene is classified as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans), based on no human data and inadequate animal data (EPA 1993a). Quantitative risk estimates are not derived for Group D substances.

E.4.3.84 Tributyl Phosphate

E.4.3.84.1 Noncancer Toxicity

Tributyl phosphate exhibits rather low acute oral toxicity; the oral single-dose LD_{50/30} in rats was 3000 mg/kg (ACGIH 1986). The compound is a weak cholinesterase inhibitor and induces paralysis and anesthesia, as well as lung edema, when given orally or parenterally (ACGIH 1986; Sandmeyer and Kirwin 1981). Irritation of the skin and mucous membranes and lung edema results from inhalation exposure. Occupational exposure to 15 mg/m³ was associated with headache and nausea.

E.4.3.84.2 Carcinogenicity

Data were not located regarding the carcinogenicity of tributyl phosphate. However, the compound was negative for mutagenicity in Salmonella and Drosophila.

E.4.3.85 1,1,1-Trichloroethane**E.4.3.85.1 Noncancer Toxicity**

The toxicity of oral exposure to 1,1,1-trichloroethane is low (ACGIH 1986). Chronic ingestion by laboratory animals reduced growth rate, but produced little pathology in internal organs (ATSDR 1990). Acute inhalation exposure of humans or animals to high levels induced death due to narcosis or cardiac sensitization (ACGIH 1986). Occupational exposure was not associated with systemic effects. The EPA (1992b) presented a provisional chronic oral RfD for 1,1,1-trichloroethane of 0.09 mg/kg/day based on an NOAEL for slight growth retardation in guinea pigs in subchronic intermittent exposure inhalation studies and an uncertainty factor of 1000. A provisional subchronic oral RfD of 0.9 mg/kg/day was based on the same NOAEL and an uncertainty factor of 100. A provisional chronic inhalation RfC of 1 mg/m³ was derived from the same NOAEL and an uncertainty factor of 1000. The provisional subchronic inhalation RfC, based on the same NOAEL and an uncertainty factor of 100, was 10 mg/m³. The chronic and subchronic inhalation RfC values are equivalent to 0.3 and 3 mg/kg/day, respectively, assuming humans inhale 20 m³ of air/day and weigh 70 kg. Target organs for inhalation exposure to 1,1,1-trichloroethane are the CNS and heart.

E.4.3.85.2 Carcinogenicity

The EPA (1993a) classifies 1,1,1-trichloroethane as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans). There are no reported human cancer data, and animal studies (78-week gavage studies in rats and mice, and a 12-month inhalation study in rats) were inadequate to determine the carcinogenicity of 1,1,1-trichloroethane in animals. Quantitative cancer risk estimates are not derived for Group D compounds.

E.4.3.86 Trichloroethene**E.4.3.86.1 Noncancer Toxicity**

Little is known about the toxicity of prolonged oral exposure to trichloroethene. Acute inhalation exposure to high levels induced anesthesia, tachypnea, and ventricular arrhythmias (ACGIH 1986). Occupational exposure was associated with headache, dizziness, lassitude, and other CNS effects. Prolonged inhalation exposure of animals affected the liver and kidneys. Neither oral nor inhalation RfD or RfC values were located for trichloroethene. The principal target organs for trichloroethene are the CNS and heart, and, to a lesser extent, the liver and kidney.

E.4.3.86.2 Carcinogenicity

Carcinogenicity studies in laboratory animals showed increased incidence of hepatocellular carcinomas (gavage exposure) and malignant lymphomas (inhalation exposure) in mice and increased incidence of renal adenocarcinomas in male rats (gavage) (EPA 1988d). Cancer studies in humans were inadequate. Interpretation of the data regarding the carcinogenicity of trichloroethene is controversial, and the EPA (1992h) has not adopted a final position on a cancer weight-of-evidence classification or quantitative risk estimates for trichloroethene. For this reason, trichloroethene was removed from the IRIS and the 1992 HEAST (EPA 1992b). Currently, EPA believes the weight-of-evidence to be on the C-B2 continuum (possible-probable human carcinogen), and offers slope factors of 0.011 per mg/kg/day for oral exposure and 0.006 per mg/kg/day for inhalation exposure as being useful.

E.4.3.87 Trichlorofluoromethane**E.4.3.87.1 Noncancer Toxicity**

One study reported no effects in rats and dogs exposed to levels equivalent to doses somewhat higher than those in the NCI (1978) gavage study (Leuschner et al. 1983). These concentrations of trichlorofluoromethane induced mild narcosis and transient cardiac sensitization (ACGIH 1986). Provisional chronic and subchronic inhalation RfC values of 0.7 and 7 mg/m³, respectively, were derived from an LOAEL for impaired kidney function and pulmonary inflammation in dogs continuously exposed to trichlorofluoromethane in air for 90 days. Uncertainty factors of 10,000 and 1000 were used for the chronic and subchronic inhalation RfC values, respectively. The chronic and subchronic RfC values are equivalent to 0.2 and 2 mg/kg/day, respectively, assuming humans inhale 20 m³ of air/day and weigh 70 kg.

A dose of 2.5 mL/kg (3700 mg/kg, assuming a density of 1.494 g/mL [Budavari 1989]) produced neither fatalities nor liver necrosis in rats.

The EPA (1993a) derived a verified chronic oral RfD of 0.3 mg/kg/day from the LOAEL for reduced survival of 349 mg/kg/day. This 78-week gavage study in rats and mice was associated with decreased survival in both species, even at the lowest dose tested (349 mg/kg/day) (NCI 1978). The cause of death was not ascertained, but pleuritis and pericarditis were observed in some of the treated rats. An uncertainty factor of 1000 was applied when calculating the RfD; factors of 10 each for inter- and intraspecies variation, and to estimate an NOAEL from an LOAEL. A provisional subchronic oral RfD of 0.7 mg/kg/day was based on an LOAEL for decreased body weights in a 6-week gavage study in rats and an uncertainty factor of 1000 (EPA 1992b). Target organs for trichlorofluoromethane include the CNS, heart, and kidney.

0625

E.4.3.87.2 Carcinogenicity

Trichlorofluoromethane has not yet been reviewed by the EPA for evidence of carcinogenicity to humans (EPA 1993a).

E.4.3.88 1,1,2-Trichloro-1,2,2-trifluoroethane

E.4.3.88.1 Noncancer Toxicity

The acute oral toxicity of 1,1,2-trichloro-1,2,2-trifluoroethane is low (ACGIH 1986). Occupational exposure to moderate levels was not associated with adverse effects, although acute exposure to grossly high levels was implicated in several dry-cleaning fatalities. CNS effects were observed in humans exposed to high levels. Inhalation exposure to very high levels in animals sensitized the heart to epinephrine, resulting in serious cardiac arrhythmia. The EPA (1993a) presented a verified chronic oral RfD of 30 mg/kg/day based on an NOAEL from an occupational study and an uncertainty factor of 10. The EPA (1992b) presented a provisional subchronic oral RfD of 3 mg/kg/day, based on an NOEL in an inhalation study in rats and an uncertainty factor of 100. It is clear that the provisional subchronic oral RfD is inappropriate because it implies that the toxic potency of subchronic exposure is greater than the toxic potency of chronic exposure. For this reason, the chronic oral RfD of 30 mg/kg/day is adopted as sufficiently protective for subchronic exposure. The EPA (1992b) also presented 27 mg/m³ as a provisional subchronic and chronic inhalation RfC, based on the rat inhalation data and an uncertainty factor of 100. The inhalation RfC is equivalent to 8 mg/kg/day, assuming an inhalation rate of 20 m³/day and a body weight of 70 kg for humans. Target organs for inhalation exposure to 1,1,2-trichloro-1,2,2-trifluoroethane are the CNS and the heart.

E.4.3.88.2 Carcinogenicity

There were no reports of carcinogenicity associated with 1,1,2-trichloro-1,2,2-trifluoroethane (ACGIH 1986).

E.4.3.89 2,4,5-Trichlorophenol

E.4.3.89.1 Pharmacokinetics

Data regarding the pharmacokinetics of 2,4,5-trichlorophenol were not located in the available literature. The log K_{ow} of 3.69 for 2,4,6-trichlorophenol, a structurally similar compound (Howard 1989), suggests that 2,4,5-trichlorophenol is probably strongly lipophilic, and that it would be absorbed from the gastrointestinal tract and through the skin. Default values for absorption efficiency of 0.9 for gastrointestinal absorption and 0.3 for dermal uptake from soil (EPA 1993d) appear to be reasonable.

E.4.3.89.2 Noncancer Effects

A chronic oral RfD of 0.1 mg/kg-day is based on a NOEL for liver and kidney effects in a subchronic study in rats (EPA 19931). An uncertainty factor of 1000 was applied; factors of 10 each to expand

from subchronic to chronic exposure, to extrapolate from animals to humans, and to account for the range of variability in human sensitivity. The subchronic oral RfD of 1.0 mg/kg-day was based on the same study and an uncertainty factor of 100 (EPA 1992b). The data were insufficient for derivation of a toxicity value for inhalation exposure.

E.4.3.89.3 Carcinogenicity

Data were not located regarding the carcinogenicity of 2,4,5-trichlorophenol. 2,4,6-Trichlorophenol, which is structurally similar to 2,4,5-trichlorophenol, is considered a probable human carcinogen (EPA weight-of-evidence Group B2) based on increased incidence of lymphomas or leukemias in male rats and hepatocellular adenomas of carcinomas in male and female mice (EPA 1993a).

E.4.3.90 Uranium

E.4.3.90.1 Noncancer Toxicity

The only chemical toxicity effect in humans unequivocally attributed to soluble uranium salts is kidney damage, involving the proximal convoluted tubule, and manifested initially as albuminuria and increased urinary catalase (Berlin and Rudell, 1986). Rabbits were more sensitive than dogs or rats. Treatment of rabbits and dogs with soluble uranium salts also induced neurologic signs and pathological changes of the nervous system. EPA (1993a) presented a verified RfD of 0.003 mg/kg/day for chronic oral exposure to soluble uranium salts. The basis was an LOAEL for kidney damage in rabbits treated with uranyl nitrate hexahydrate in the diet for 30 days, and an uncertainty factor of 1000. A subchronic oral RfD was not located. The principal target organ for the chemical toxicity of soluble salts of uranium is the kidney; the CNS may be an additional target organ.

E.4.3.90.2 Carcinogenicity

Uranium can induce cancer as a result of intake into the body through inhalation or ingestion pathways. The induction of cancer results when organs and tissues of the body are exposed to alpha particles emitted from decaying uranium atoms. Alpha particles are energetic emissions that cause molecular ionizations in a very dense pattern along a short path through matter. The effect of an alpha particle is highly localized due to the short path length traveled (low penetrability) and the ability of the particle to produce many ionizations. The ionization events cause biological damage that is believed to be responsible for inducing cells to become cancerous. Although other energetic emissions from radioactive decay of atoms (such as beta particles and gamma rays) also cause molecular ionizations, these radiations do not produce the density of ionizations that alpha particles produce. The dense pattern of ionizations caused by alpha particles and the low penetrability of alpha particles are the factors that determine uranium is an internal exposure hazard. Alpha particles are not an external exposure hazard because they do not penetrate sensitive tissues from outside the body. The outer layers of the skin stop the alpha particles before they can penetrate to and damage sensitive tissues of inner layers.

The type of uranium (e.g. natural, enriched, depleted) under consideration is important because different types of uranium have different specific activities (the amount of radioactivity per unit mass). The magnitude of the specific activity of the uranium reflects the number of alpha particles emitted per unit mass. This has a direct impact on the magnitude of the radiological dose delivered internally after the uranium enters the body. Naturally-occurring uranium and uranium processed from natural uranium is a mixture of U-234, U-235, and U-238. The difference between natural, enriched, and depleted uranium is defined by the percent U-235 mass enrichment. The higher the U-235 enrichment, the higher the specific activity of the mixture.

The following discussion of human data concerning health effects of uranium exposure is summarized from the report of the BEIR IV Committee on radon and other alpha emitters (NAS 1988). Convincing epidemiological evidence of uranium-induced radiocarcinogenic effects in humans is difficult to obtain. Available epidemiological evidence comes from studies of workers involved in uranium mining and milling operations. It has been noted for some time that uranium workers are at risk of increased cancer mortality; however, inhalation of airborne radon progeny rather than uranium particulates is considered the predominant source of radiation damage to the respiratory tract in uranium miners. Simultaneous exposures to radon progeny and other elements present in uranium ore are considered confounding factors in studies of uranium miners intended to specifically examine the radiological effects of exposure to uranium.

Risk estimation for exposure to uranium is based heavily on the carcinogenic effects of other alpha-emitting radionuclides and animal experiments involving exposure to uranium. Available human epidemiological studies are discussed as follows.

Epidemiological surveys of uranium workers began in the United States in 1950 (Miller et al. 1956) and reports of increased cancer risk among uranium millers in Europe first began in 1959 (Rockstroh 1959). In contrast, other studies have indicated that there is little evidence of a health hazard to workers in the uranium processing industry (Ely 1959). The BEIR IV report (NAS 1988) cautions that the validity of epidemiological studies on effects of uranium must be considered in the context of the power or ability of the studies to detect an effect if one existed. This question is important with regard to all of the available epidemiological studies on uranium effects.

An early U.S. Public Health Service study of uranium miners and millers in the Colorado Plateau reported no increase in mortality in the cohort of uranium millers studied (Wagoner et al. 1964). A more detailed study with longer follow-up of the same cohort was performed (Archer et al. 1973). The number of deaths available for analysis was almost equal to the expected number of deaths determined among controls. Interpretation of the results is complicated by the fact that exposure data are not available, the excess cases include three diagnostic categories, precautions taken to exclude individuals with underground mining exposure through previous employment were not stated, and the

4787
analysis was not performed in relation to the length of exposure. The study does not provide strong evidence that uranium has a specific effect because of the weak epidemiological power of the study.

Studies of uranium workers exposed to enriched uranium have been performed. A study of workers at the enrichment facility in Oak Ridge between 1943 and 1947 indicated that the mortality of the study cohort was not increased for lung cancer, bone cancer, or nephrotoxic disorders (Polednak and Frome 1986). This study is weakened by the fact that it is based on exposures of short duration (typically 1 to 2 years), which does not provide conclusive evidence concerning health effects from long-term (chronic) exposure. Subsequent study of a cohort from the same population was performed to examine lung cancer risk from inhalation exposure of uranium dust (Cookfair et al. 1983). The results indicate an increased risk among the group of workers hired at an age over 45, and the magnitude of the increase was greater for higher exposures.

A retrospective study of uranium mill workers from the Colorado Plateau was conducted to examine the health risks of uranium exposure in the absence of uranium mining (Waxweiler et al. 1983). The findings of the study were not statistically significant and are mitigated by the small number of deaths available for workers employed for at least five years. The results did not reveal an increase in lung cancer deaths and did not conclusively demonstrate an increased nephrotoxic effect.

The available epidemiological studies fail to conclusively demonstrate health effects from chronic exposure to uranium dust involved in uranium mining and milling operations. However, it is not necessarily concluded that the epidemiological data conclusively demonstrate the absence of effect. This is because the power of the studies is limited, weakened by short worker exposure durations, inadequate estimates of uranium exposures, and insufficient worker follow-up time to adequately evaluate long-term effects.

In conclusion, chronic exposure to uranium should be controlled on the basis of nephrotoxicity more than by radiocarcinogenicity from alpha particle emissions (NAS 1988). Quantification of the risk from chronic exposure to uranium alpha particles cannot be determined from published epidemiological studies because of confounding factors and the limited power of the studies to detect increased rates of cancer incidence or mortality (NAS 1988). Therefore, the BEIR IV Committee presents a risk estimate for uranium based on the carcinogenic effects of other alpha-emitting radionuclides and animal experiments involving exposure to uranium. The most probable radiogenic effect is an increase in bone sarcomas. The likelihood of sarcomas from exposure to naturally-occurring uranium is considered low and only demonstratable if a linear dose-response relationship is assumed (Mays et al. 1985). If the dose-response relationship is quadratic, then virtually no effect would be expected from naturally-occurring uranium. Assuming a linear dose-response relationship and a constant nonoccupational uranium intake of 1 pCi/day the risk of bone sarcoma induction over a

06.29

lifetime is estimated to be 1.5 bone sarcomas per million persons (1.5E-06) (Mays et al. 1985). This is compared to a natural incidence of 750 bone sarcomas in the absence of excess exposure.

Assuming a constant nonoccupational uranium intake rate of 1 pCi/day, an exposure frequency of 365 days/year, and a lifetime of 70 years, a lifetime intake of uranium of nearly 26,000 pCi is calculated. Using the risk factor from Mays (Mays et al. 1985) and dividing by the calculated lifetime intake, one can derive a risk factor of 5.9E-11 per pCi. Comparison of this risk factor with the cancer slope factors from HEAST for ingestion of U-234, U-235, and U-238 indicates that the ratios of the HEAST values to the former value are 2.4, 2.2, and 2.2, respectively.

The following discussion of experimental animal data concerning health effects of uranium exposure is summarized from the report of the BEIR IV Committee on radon and other alpha emitters (NAS 1988). The effect of bone cancer induction is addressed first, followed by the effect of lung cancer induction.

The discussion involving human epidemiological evidence identified the bone surfaces as the most probable target tissue for exposure to uranium and bone sarcoma as the carcinogenic effect of concern. Radiocarcinogenic effects including bone sarcoma and head carcinoma have also been observed in animals and humans from exposure to isotopes of radium, and studies involving exposure of mice to high specific activity U-232 and U-233 also reveal an increase in bone sarcomas. Soviet researchers have demonstrated that highly enriched uranium, which has a high specific activity, induces bone sarcomas in rats. These results indicate that intake of high specific activity, alpha-particle-emitting radionuclides increases the risk of these cancers in animals. It would be reasonable to expect high specific activity uranium to induce bone sarcomas in humans; however, the likelihood that low specific activity, naturally-occurring uranium induces bone sarcomas is low.

The discussion of human epidemiological evidence states that an estimate of the excess risk of bone sarcoma in humans from chronic ingestion of uranium has been developed (Mays et al. 1985). This risk estimate is based on a linear dose-response relationship for Ra-226. Therefore, it is assumed that the response to alpha particles from uranium exposure is similar to the response to alpha particles from Ra-226. This assumption is dependent in part on the metabolic behavior of uranium relative to radium. There is evidence indicating that uranium seeks bone tissue in a manner similar but not identical to that of radium. Uranium-233 administered to beagle dogs has been shown to initially deposit nonuniformly on bone surfaces; however, redistribution occurs (within approximately one year) to produce a distribution through the bone volume that is similar to the distribution of radium (Stevens et al. 1980). Distribution of uranium throughout the bone volume in dogs has also been reported by Rowland and Farnham (1969) and Bruenger (personal communication with BEIR IV Committee, 1986 not available in bibliography).

The induction of malignant tumors in the lung is of concern for exposure to uranium by inhalation. As previously discussed, uranium emits alpha particles, which can deposit a highly localized radiation dose to sensitive tissues in the passages of the respiratory tract if particulate uranium is deposited in those passageways. The effects of inhalation of insoluble forms of uranium have been studied in rats, dogs, and monkeys for both short and prolonged exposure scenarios (Leach et al. 1970, 1973). Affected sites for insoluble forms of uranium are the tissues of the lung and the pulmonary lymph nodes. Chronic inhalation of uranium in these studies produced fibrosis of lung tissue and induction of malignant lung tumors. Data from those inhalation studies that involved dogs have been reanalyzed (Durbin and Wrenn 1975), leading to the conclusion that neoplastic changes (tumor induction) began in epithelial cells of the lungs in 21 percent of the dogs after a cumulative lung dose of 160 rads.

Another study involving exposure of rats to U-232 and U-233 (as uranyl nitrate) by inhalation reveals an increase in malignant lung tumors and bone sarcomas (Ballou et al. 1980). However, the significance of the bone sarcomas (osteosarcomas) is questionable because the rats exposed to control aerosols also developed these tumors. The osteosarcomas are not statistically significant because of their appearance in the control rats. The results of this study of high specific activity U-232 and U-233 labeled uranyl nitrate can lead to the reasonable expectation that such exposure can induce malignant lung tumors in humans. However, the findings of this work do not provide the data needed to convincingly extrapolate a risk coefficient for human exposure.

E.4.3.91 Vanadium

E.4.3.91.1 Noncancer Toxicity

The oral toxicity of vanadium compounds to humans is very low (Lagerkvist et al. 1986), probably because little vanadium is absorbed from the GI tract. Effects in humans exposed by inhalation include upper and lower respiratory tract irritation. A provisional subchronic and chronic oral RfD of 0.007 mg/kg/day was derived from an NOEL in rats in a lifetime drinking water study with vanadyl sulfate and an uncertainty factor of 100 (EPA 1992b). A target organ could not be identified for oral exposure. The respiratory tract is the target organ for inhalation exposure.

E.4.3.91.2 Carcinogenicity

No information was located regarding the carcinogenicity of vanadium.

E.4.3.92 Vinyl Chloride

E.4.3.92.1 Noncancer Toxicity

Data were not located regarding oral exposure of humans to vinyl chloride (ATSDR 1989i). In rats, lifetime dietary ingestion of vinyl chloride slightly but significantly increased mortality and induced mild histopathologic effects in the liver. Several early occupational studies associated vinyl chloride

exposure with a syndrome known as vinyl chloride disease, which includes acroosteolysis (dissolution of the ends of the distal phalanges of the hands), circulatory disturbances in the extremities, Raynaud syndrome (sudden, recurrent bilateral cyanosis of the digits), scleroderma, hematologic effects, effects on the lungs, and impaired liver function and liver damage. Mild neurologic effects were also associated with occupational exposure. Long-term inhalation studies in rats and mice identified elevated relative liver weight as a sensitive indicator of liver effects. Neither inhalation RfC values nor oral RfD values for vinyl chloride were located. The principal target organs for vinyl chloride appear to be the CNS and the liver.

E.4.3.92.2 Carcinogenicity

The EPA (1992b) lists vinyl chloride as an EPA cancer weight-of-evidence Group A compound (human carcinogen) and presents a verified oral slope factor of 1.9 per mg/kg/day, based on the increased incidence of liver and lung tumors in a lifetime dietary study in rats. An inhalation unit risk of $8.4\text{E-}05$ per $\mu\text{g}/\text{m}^3$, equivalent to 0.3 per mg/kg/day, assuming humans inhale 20 m^3 of air/day and weigh 70 kg, is based on liver tumors in rats intermittently exposed by inhalation for 12 months.

E.4.3.93 Xylenes

E.4.3.93.1 Noncancer Toxicity

Prolonged oral exposure of animals to xylenes was associated with CNS signs and increased mortality, without histopathological alterations in the internal organs (EPA 1993a). Occupational exposure to xylenes induced CNS effects and GI disturbances (ACGIH 1986). Other effects attributed to occupational exposure to xylene (blood dyscrasias, and heart, liver, and kidney damage) may have arisen from concurrent exposure to other chemicals. The EPA (1993a) presented a chronic oral RfD for total xylenes of 2 mg/kg/day based on an NOAEL for hyperactivity and decreased body weight and increased mortality in male rats in chronic gavage studies. An uncertainty factor of 100 was used. The EPA (1992b) presented a subchronic oral RfD of 4 mg/kg/day based on an NOEL for body weight effects in a 13-week gavage study in rats and an uncertainty factor of 100. Inhalation RfC values for xylenes are considered not verifiable by the RfD/RfC Work Group (EPA 1992b). The CNS is the principal target organ for xylenes.

E.4.3.93.2 Carcinogenicity

Xylene is classified as a cancer weight-of-evidence Group D compound (not classifiable as to carcinogenicity to humans) (EPA 1993a). There are no reported human cancer data, and gavage animal studies in rat and mice of both sexes did not result in significant increases in tumor incidence. Quantitative risk estimates are not derived for Group D substances.

E.4.3.94 ZincE.4.3.94.1 Pharmacokinetics

Zinc is a nutritionally required trace element. Estimates of the efficiency of GI absorption of zinc in animals range from <10 to 90 percent (Elinder 1986c). Estimates in normal humans range from approximately 20 to 77 percent (Elinder 1986; Goyer 1991). The net absorption of zinc appears to be homeostatically controlled, but it is unclear whether GI absorption, intestinal secretion, or both are regulated. Distribution of absorbed zinc is primarily to the liver (Goyer 1991), with subsequent redistribution to bone, muscle, and kidney (Elinder 1986). Highest tissue concentrations are found in the prostate. Excretion appears to be principally through the feces, in part from biliary secretion, but the relative importance of fecal and urinary excretion is species-dependent. The half-life of zinc absorbed from the GI tracts of humans in normal zinc homeostasis is approximately 162 to 500 days.

E.4.3.94.2 Noncancer Toxicity

Humans exposed to high concentrations of aerosols of zinc compounds may experience severe pulmonary damage and death (Elinder 1986). The usual occupational exposure is to freshly formed fumes of zinc, which can induce a reversible syndrome known as metal fume fever. Orally, zinc exhibits a low order of acute toxicity. Animals dosed with 100 times dietary requirement showed no evidence of toxicity (Goyer 1991). In humans, acute poisoning from foods or beverages prepared in galvanized containers is characterized by GI upset (Elinder 1986). Chronic oral toxicity in animals is associated with poor growth, GI inflammation, arthritis, lameness, and a microcytic, hypochromic anemia (Elinder 1986), possibly secondary to copper deficiency (Underwood 1977). The EPA (1992b) presented a verified RfD of 0.2 mg/kg/day for chronic oral exposure to zinc, based on anemia in humans.

E.4.3.94.3 Carcinogenicity

The EPA (1993a) classifies zinc in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans) based on inadequate evidence for carcinogenicity in humans and animals. The human data consist largely of occupational exposure studies not designed to detect a carcinogenic response, and of reports that prostatic zinc concentrations were lower in cancerous than in noncancerous tissue. The animal data consist of several dietary, drinking water, and zinc injection studies, none of which provided convincing data for a carcinogenic response.

TABLE E.4-1

CANCER SLOPE FACTORS FOR OPERABLE UNIT 1 RADIONUCLIDES OF CONCERN
UPDATED: 9/23/93

Radionuclide	ICRP Lung Class ^a	Inhalation (pCi) ⁻¹	GI Absorption Factor (f ₁)	Ingestion (pCi) ⁻¹	Penetrating External Exposure (pCi.yr/g) ⁻¹
Ac-227 + 7 dtrs	Y	8.8×10^{-8}	1.0×10^{-3}	3.5×10^{-10}	8.5×10^{-7}
Am-241	W	3.2×10^{-8}	1.0×10^{-3}	2.4×10^{-10}	4.9×10^{-9}
Cs-137 + dtr	D	1.9×10^{-11}	1.0×10^0	2.8×10^{-11}	2.0×10^{-6}
Np-237 + dtr	W	2.9×10^{-8}	1.0×10^{-3}	2.2×10^{-10}	4.3×10^{-7}
Pa-231	Y	3.6×10^{-8}	1.0×10^{-3}	9.2×10^{-11}	2.6×10^{-8}
Pb-210 + 2 dtrs	D	4.0×10^{-9}	2.0×10^{-1}	6.6×10^{-10}	1.6×10^{-10}
Pu-238	Y	3.9×10^{-8}	1.0×10^{-3}	2.2×10^{-10}	2.8×10^{-11}
Pu-239/240	Y	3.8×10^{-8}	1.0×10^{-3}	2.3×10^{-10}	2.7×10^{-11}
Ra-226 + 5 dtrs	W	3.0×10^{-9}	2.0×10^{-1}	1.2×10^{-10}	6.0×10^{-6}
Ra-226 + 8 dtrs	W	7.0×10^{-9}	2.0×10^{-1}	7.8×10^{-10}	$6/0 \times 10^{-6}$
Ra-228 + dtr	W	6.9×10^{-10}	2.0×10^{-1}	1.0×10^{-10}	2.9×10^{-6}
Rn-222 + 4 dtrs	*	7.7×10^{-12}	1.0×10^0	1.7×10^{-12}	5.9×10^{-6}
Ru-106	Y	4.4×10^{-10}	5.0×10^{-2}	9.5×10^{-12}	0.0×10^0
Sr-90 + dtr	D	6.2×10^{-11}	3.0×10^{-1}	3.6×10^{-11}	0.0×10^0
Tc-99	W	8.3×10^{-12}	8.0×10^{-1}	1.3×10^{-12}	6.0×10^{-13}
Th-228 + 7 dtrs	Y	7.8×10^{-8}	2.0×10^{-4}	5.5×10^{-11}	5.6×10^{-6}

TABLE E.4-1
(Continued)

Radionuclide	ICRP Lung Class ^a	Inhalation (pCi) ⁻¹	GI Absorption Factor (f ₁)	Ingestion (pCi) ⁻¹	Penetrating External Exposure (pCi-yr/g) ⁻¹
Th-230	Y	2.9 x 10 ⁻⁸	2.0 x 10 ⁻⁴	1.3 x 10 ⁻¹¹	5.4 x 10 ⁻¹¹
Th-232	Y	2.8 x 10 ⁻⁸	2.0 x 10 ⁻⁴	1.2 x 10 ⁻¹¹	2.6 x 10 ⁻¹¹
Th-232 + 10 dtrs	Y	1.1 x 10 ⁻⁷	2.0 x 10 ⁻¹	1.7 x 10 ⁻¹⁰	8.5 x 10 ⁻⁶
U-233	Y	2.7 x 10 ⁻⁸	5.0 x 10 ⁻²	1.6 x 10 ⁻¹¹	4.2 x 10 ⁻¹¹
U-234	Y	2.6 x 10 ⁻⁸	5.0 x 10 ⁻²	1.6 x 10 ⁻¹¹	3.0 x 10 ⁻¹¹
U-235 + dtr	Y	2.5 x 10 ⁻⁸	5.0 x 10 ⁻²	1.6 x 10 ⁻¹¹	2.4 x 10 ⁻⁷
U-238 + 2 dtrs	Y	5.2 x 10 ⁻⁸	5.0 x 10 ⁻²	2.8 x 10 ⁻¹¹	3.6 x 10 ⁻⁸

^aClassification recommended by the ICRP for half-time for clearance from the lung. "Y" = years, "W" = weeks, "D" = days, "*" = gas.

4782

E-488

0635

TABLE E.4-2

TOXICITY VALUES FOR OPERABLE UNIT 1 CHEMICALS OF POTENTIAL CONCERN

Chemical Name	Subchronic Oral RfD Source (mg/kg-day)	Chronic Oral RfD Source (mg/kg-day)	Subchronic Inhalation RfC or RfD Source (mg/m ³)	Chronic Inhalation RfC or RfD Source (mg/m ³)	Cancer Group	Oral Slope Factor Source (mg/kg-day) ⁻¹	Inhalation Slope Factor or Unit Risk Source
Antimony		4 x 10 ^{-4a}			D*		
Arsenic		3 x 10 ^{-4a}			A*	0.00005/ μ g/l ^a (1.8 x 10 ⁰)	0.0043/ μ g/m ^{3a} (1.5 x 10 ¹) ^a
Barium	7 x 10 ^{-2b}	7 x 10 ^{-2a}	5 x 10 ^{-3b}	1.4 x 10 ^{-6bd}	D*		
Beryllium	5 x 10 ^{-3b}	5 x 10 ^{-3a}			B2	4.3 x 10 ^{0a}	8.4 x 10 ^{0a}
Boron	9 x 10 ^{-2b}	9 x 10 ^{-2a}		5.7 x 10 ^{-3bd}	D*		
Cadmium		5 x 10 ^{-4a} (water) 1 x 10 ^{-3a} (food)			B1*		6.1 x 10 ^{0a}
Chromium (III)	1 x 10 ^{1b}	1 x 10 ^{0a}					
Chromium (VI)	2 x 10 ^{-2b}	5 x 10 ^{-3a}			A*		4.1 x 10 ^{1b}
Cobalt		6 x 10 ⁻²		3 x 10 ^{-7a}			
Copper and compounds		3.7 x 10 ^{-2a}			D*		
Cyanide	2 x 10 ^{-2b}	2 x 10 ^{-2a}			D		
Lead					B2*		
Manganese		5 x 10 ^{-3a} (water) 1.4 x 10 ^{-1a} (food)	4 x 10 ^{-6b}	1.1 x 10 ^{-4ad}	D*		
Mercury		3 x 10 ^{-4a}		8.6 x 10 ^{-5bd}	D*		
Molybdenum	4 x 10 ^{-2b}	5 x 10 ^{-3a}			D*		
Nickel	2 x 10 ^{-2b}	2 x 10 ^{-2a}			A		8.4 x 10 ^{-1b}
Selenium	5 x 10 ^{-3b}	5 x 10 ^{-3a}			D		
Silver		5 x 10 ^{-3a}			D*		
Thallium, soluble salts		6 x 10 ⁻⁵ (derived)					

TABLE E.4-2
(Continued)

Chemical Name	Subchronic Oral RfD Source (mg/kg-day)	Chronic Oral RfD Source (mg/kg-day)	Subchronic Inhalation RfC or RfD Source (mg/m ³)	Chronic Inhalation RfC or RfD Source (mg/m ³)	Cancer Group	Oral Slope Factor Source (mg/kg-day) ⁻¹	Inhalation Slope Factor or Unit Risk Source
Tin	6 x 10 ⁻¹	6 x 10 ^{-1a}					
Uranium, soluble salts		3 x 10 ^{-3a}			A		
Vanadium	7 x 10 ^{-3b}	7 x 10 ^{-3b}			D*		
Zinc		3 x 10 ^{-1a}			D*		
2-Methylnaphthalene							
4,4'-DDT		5 x 10 ^{-4a}			B2*		3.4 x 10 ^{-1a}
4-Nitroaniline		3 x 10 ^{-3c}					
4-Nitrophenol		6 x 10 ^{-2c}			D*		
2,4,5-Trichlorophenol	1 x 10 ^{0a}	1 x 10 ^{-1a}					
Acenaphthene	6 x 10 ^{-1b}	6 x 10 ^{-2a}					
Acenaphthylene					D		
Anthracene	3 x 10 ^{0b}	3 x 10 ^{-1a}			D		
Benzo(a)pyrene					B2	7.3	6.1
Benzo(ghi)perylene					D		
Benzene					A*	2.9 x 10 ^{-2a}	2.9 x 10 ^{-2a}
Dibenzofuran					D		
Dioxins/furans					B2*	1.5 x 10 ^{5a}	
Dichlorodifluoromethane		2 x 10 ^{-1a}		5.7 x 10 ^{-2nd}	D		
Fluoranthene	4 x 10 ^{-1b}	4 x 10 ^{-2a}			D		
Fluorene	4 x 10 ^{-1b}	4 x 10 ^{-2a}			D		
Naphthalene	4 x 10 ^{-2b}	4 x 10 ^{-2b}			D		
Polychlorinated biphenyls					B2	7.7 x 10 ^{0a}	

4287

E-490 . 0637

TABLE E.4-2
(Continued)

Chemical Name	Subchronic Oral RfD Source (mg/kg-day)	Chronic Oral RfD Source (mg/kg-day)	Subchronic Inhalation RfC or RfD Source (mg/m ³)	Chronic Inhalation RfC or RfD Source (mg/m ³)	Cancer Group	Oral Slope Factor Source (mg/kg-day) ⁻¹	Inhalation Slope Factor or Unit Risk Source
Pentachlorophenol	3 x 10 ^{-2b}	3 x 10 ^{-2a}			B2 ^a	1.2 x 10 ^{-1a}	
Phenanthrene					D		
Pyrene	3 x 10 ^{-1b}	3 x 10 ^{-2a}			D		
Tributyl phosphate		5 x 10 ^{-3a}					
Tetrachloroethene	1 x 10 ^{-1b}	1 x 10 ^{-2a}			C-B2	5.2 x 10 ⁻²	2 x 10 ⁻³
Vinyl chloride					A ^b	1.9 x 10 ^{0b}	3 x 10 ^{-1b}

^aEPA 1992a, IRIS (Integrated Risk Information System), on-line database.

^bEPA 1992b, Health Effects Assessment Summary Tables, annual update FY 1992, including Supplement A, July 1992.

^cEPA 1993c, Risk Based Concentration Tables.

^dDerived from unit risk or reference concentration.

^eDerived from action level of 1.3 mg/L.

787

TABLE E.4-3
DIOXIN AND FURAN TOXICITY EQUIVALENCY FACTORS^a

Compound	TEF
Dioxins	
Mono-, Di-, and Trichlorodibenzo-p-dioxins	0
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	1
Other TCDDs	0
2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDDs)	0.5
Other PeCDDs	0
2,3,7,8-Hexachlorodibenzo-p-dioxins (HxCDDs)	0.1
Other HxCDDs	0
2,3,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	0.01
Other HpCDDs	0
Octachlorodibenzo-p-dioxin (OCDD)	0.001
Furans	
Mono-, Di-, and Trichlorodibenzo-p-furans	0
2,3,7,8-Tetrachlorodibenzo-p-furan (TCDF)	0.1
Other TCDFs	0
1,2,3,7,8-Pentachlorodibenzo-p-furan (PeCDF)	0.05
2,3,4,7,8-Pentachlorodibenzo-p-furan (PeCDF)	0.5
Other PeCDFs	0
2,3,7,8-Hexachlorodibenzo-p-furans (HxCDFs)	0.1
Other HxCDFs	0
2,3,7,8-Heptachlorodibenzo-p-furans (HpCDFs)	0.01
Other HpCDFs	0
Octachlorodibenzo-p-furan (OCDF)	0.001

^aEPA 1989j

0639

TABLE E.4-4
TOXICITY EQUIVALENCY FACTORS (TEFs)^a
AND CORRESPONDING ORAL AND INHALATION SLOPE FACTORS
FOR THE GROUP B2 PAHs

4787

PAH	Relative Potency	Oral Slope Factor (mg/kg-day) ⁻¹	Inhalation Slope Factor (mg/kg-day) ⁻¹
Benzo(a)pyrene	1.0	7.3	6.1
Benzo(a)anthracene	0.145	1.1	0.89
Benzo(b)fluoranthene	0.1228	0.90	0.75
Benzo(k)fluoranthene	0.0523	0.38	0.32
Chrysene	0.0044	0.032	0.027
Dibenzo(a,h)anthracene	1.11	8.1	6.8
Indeno(1,2,3-cd)pyrene	0.278	2.0	1.7

^aClement International 1990.

TABLE E.4-5

DERMAL REFERENCE DOSES AND CANCER SLOPE FACTORS FOR
CHEMICAL CONSTITUENTS OF POTENTIAL CONCERN

Chemical	Gastrointestinal Absorption Fraction	Dermal Reference Dose (mg/kg-day)	Dermal Slope Factor (mg/kg-day) ⁻¹
Inorganics			
Antimony	0.15 ^a	6.00×10^{-5}	ND ^b
Arsenic	0.95 ^h	2.85×10^{-4}	1.90×10^0
Barium	0.91 ^{g,h}	6.37×10^{-2}	ND
Beryllium	0.01 ^h	5.00×10^{-5}	4.30×10^2
Boron	0.05 ^c	4.50×10^{-3}	ND
Cadmium (food) (water)	0.05 ^a	5.00×10^{-5} 2.50×10^{-5}	ND ND
Chromium (VI)	0.45 ^a	2.25×10^{-3}	ND
Cobalt	0.45 ^a	2.70×10^{-2}	ND
Copper	0.6 ^h	2.20×10^{-2}	ND
Cyanide	0.72 ^d	ND ^h	ND
Lead	NA ^j	ND	ND
Manganese (food) (water)	0.03 ^a	4.20×10^{-3} 1.50×10^{-4}	ND ND
Mercury	0.15 ^h	4.50×10^{-5}	ND
Molybdenum	0.38 ^a	1.90×10^{-3}	ND
Nickel	0.05 ^c	2.00×10^{-3}	ND
Selenium	0.8 ^a	4.00×10^{-3}	ND
Silver	0.05 ^c	ND ^h	ND
Thallium	1 ^a	6.00×10^{-5}	ND
Tin	0.05 ^c	3.00×10^{-2}	ND
Uranium	0.05 ^c	1.50×10^{-4}	ND ^e

TABLE E.4-5
(Continued)

4787

Chemical	Gastrointestinal Absorption Fraction	Dermal Reference Dose (mg/kg-day)	Dermal Slope Factor (mg/kg-day) ⁻¹
Vanadium	0.05 ^c	3.50×10^{-4}	ND
Zinc	0.25 ^h	7.50×10^{-2}	ND
Volatiles			
Tetrachloroethene	0.9 ^f	9.00×10^{-3}	5.78×10^{-2}
Vinyl chloride	0.9 ^g	ND	2.11×100^0
Semivolatiles			
Acenaphthene	1.0 ^g	6.00×10^{-2}	ND
Acenaphthylene	0.43 ^a	ND	ND
Anthracene	0.43 ^a	1.29×10^{-1}	ND
Benzo(a)anthracene	0.43 ^a	ND	ND
Benzo(a)pyrene	0.43 ^a	ND	ND
Benzo(b)fluoranthene	0.43 ^a	ND	ND
Benzo(g,h,i)perylene	0.43 ^a	ND	ND
Benzo(k)fluoranthene	0.43 ^a	ND	ND
Chrysene	0.43 ^a	ND	ND
Dibenzo(a,h)anthracene	0.43 ^a	ND	ND
Dibenzofuran	NA ^k	ND	ND
Fluoranthene	0.43 ^a	1.72×10^{-2}	ND
Fluorene	0.5 ^g	2.00×10^{-2}	ND
Indeno(1,2,3-cd)pyrene	0.43 ^a	ND	ND
2-Methylnaphthalene	1.0 ^g	ND	ND
Naphthalene	1.0 ^g	4.00×10^{-2}	ND
4-Nitroaniline	0.9 ^f	2.70×10^{-3}	ND

4788

TABLE E.4-5
(Continued)

Chemical	Gastrointestinal Absorption Fraction	Dermal Reference Dose (mg/kg-day)	Dermal Slope Factor (mg/kg-day) ⁻¹
4-Nitrophenol	0.9 ^f	7.20 x 10 ⁻³	ND
Pentachlorophenol	0.9 ^f	2.70 x 10 ⁻³	1.33 x 10 ⁻¹
Phenanthrene	0.9 ^f	ND	ND
Pyrene	0.43 ^f	1.29 x 10 ⁻²	ND
2,4,5-Trichlorophenol	0.9 ^f	9.00 x 10 ⁻²	ND
Tributyl phosphate	0.9 ^f	4.50 x 10 ⁻³	ND
Pesticides PCBs			
Polychlorinated biphenyls	0.75 ^a	5.30 x 10 ⁻⁵	1.03 x 10 ⁻¹
4,4'-DDT	0.9 ^g	4.50 x 10 ⁻⁴	3.78 x 10 ⁻¹
Dioxins/furans	0.5 ⁱ	ND	3.00 x 10 ⁻⁵

^aSee the Toxicity Profile for this chemical in Section E.4.4.4

^bND - Not derived

^cEPA 1989a, "Risk Assessment Guidance For Superfund, Volume, Human Health Evaluation Manual (Part A), "EPA/540/1-89/002, pp. A-2 to A-3

^dATSDR, 1988j

^eThe carcinogenicity of uranium is due to its radioactivity rather than chemical toxicity; its cancer potency due to penetrating external radiation is presented in Table E.4-1.

^fSection E.4.1.4

^gJones, T. D. and B. A. Owen, 1989, "Health Risks from Mixtures of Radionuclides and Chemicals in Drinking Water," Oak Ridge National Laboratory, Oak Ridge, Tennessee, ORNL-6533

^hEPA 1993d, Memorandum from J. Dollarhide ECAO to P. VanLeeuwen Region V, 7/21/93, including Attachments 1-6.

ⁱATSDR 1990, "Toxicological Profile for 2,3,7,8-Tetrachlorodibenzo-p-dioxin," Draft for Public Comment, U.S. Public Health Service, Atlanta, Georgia.

^jNA - Not appropriate.

^kNA - Not available.

TABLE E.4-6

DERMAL ABSORPTION COEFFICIENTS AND HENRY'S LAW CONSTANTS
USED IN EXPOSURE MODEL

Constituent	Water Permeability Coefficient (cm/hr)	Soil Absorption Coefficient (unitless)	Henry's Law Constant (atm-m ³ /mol)	Log K _{ow}
Inorganics				
Ammonia	1.00 x 10 ^{-3a}	1.00 x 10 ^{-2c}	ND ^h	ND
Antimony	1.00 x 10 ^{-3a}	1.00 x 10 ^{-2b}	ND	ND
Arsenic	1.00 x 10 ^{-3a}	1.00 x 10 ^{-3c}	ND	ND
Barium	1.00 x 10 ^{-3a}	1.00 x 10 ^{-2b}	ND	ND
Beryllium	1.00 x 10 ^{-3a}	1.00 x 10 ^{-2b}	ND	ND
Boron	1.00 x 10 ^{-3a}	1.00 x 10 ^{-2b}	ND	ND
Cadmium (food)	1.00 x 10 ^{-3a}	1.00 x 10 ^{-2b}	ND	ND
Chromium	2.00 x 10 ^{-3a}	1.00 x 10 ^{-2b}	ND	ND
Cobalt	4.00 x 10 ^{-4a}	1.00 x 10 ^{-2b}	ND	ND
Cyanide	1.00 x 10 ^{-3a}	1.00 x 10 ^{-2b}	ND	ND
Copper	1.00 x 10 ^{-3a}	1.00 x 10 ^{-3c}	ND	ND
Fluoride	1.00 x 10 ^{-3a}	1.00 x 10 ^{-2c}	ND	ND
Lead	4.00 x 10 ^{-6a}	1.00 x 10 ^{-2b}	ND	ND
Manganese	1.00 x 10 ^{-3a}	1.00 x 10 ^{-2b}	ND	ND
Mercury	1.00 x 10 ^{-4a}	5.00 x 10 ^{-2c}	ND	ND
Molybdenum	1.00 x 10 ^{-3a}	1.00 x 10 ^{-2b}	ND	ND
Nickel	1.00 x 10 ^{-4a}	5.00 x 10 ^{-4c}	ND	ND
Nitrate	ND	ND	ND	ND
Phosphorous	ND	1.00 x 10 ^{-1c}	ND	ND
Selenium	1.00 x 10 ^{-3a}	1.00 x 10 ^{-2b}	ND	ND
Silver	6.00 x 10 ^{-4a}	1.00 x 10 ^{-2b}	ND	ND
Thallium	1.00 x 10 ^{-3a}	1.00 x 10 ^{-2b}	ND	ND
Tin	1.00 x 10 ^{-3a}	1.00 x 10 ^{-3b}	ND	ND
Uranium	1.00 x 10 ^{-3a}	1.00 x 10 ^{-2b}	ND	ND
Vanadium	1.00 x 10 ^{-3a}	1.00 x 10 ^{-3c}	ND	ND
Zinc	6.00 x 10 ^{-4a}	1.00 x 10 ^{-2b}	ND	ND

TABLE E.4-6
(Continued)

4787

Constituent	Water Permeability Coefficient (cm/hr)	Soil Absorption Coefficient (unitless)	Henry's Law Constant (atm-m ³ /mol)	Log K _{ow}
Volatile Organics				
Benzene	2.10 x 10 ^{-2a}	5.00 x 10 ^{-4c}	5.59 x 10 ^{-3f}	2.13 ^f
Tetrachloroethene	5.30 x 10 ^{-2e}	4.00 x 10 ^{-1c}	2.87 x 10 ^{-2f}	2.53 ^f
Vinyl Chloride	3.70 x 10 ^{-3a}	3.00 x 10 ^{-1c}	8.19 x 10 ^{-2f}	0.60 ^f
Semivolatile Organics				
2-Methylnaphthalene	ND	3.00 x 10 ^{-1c}	ND	3.86 ^f
3,3'-Dichlorobenzidine	ND	ND	ND	3.50 ^f
Acenaphthylene	1.74 x 10 ^{-1a}	3.00 x 10 ^{-1c}	1.14 x 10 ^{-4f}	4.07 ^f
Acenaphthene	ND	3.00 x 10 ^{-1c}	ND	3.92 ^f
Anthracene	2.25 x 10 ^{-1a}	4.00 x 10 ^{-1c}	8.60 x 10 ^{-3f}	4.45 ^f
Benzo(g,h,i)perylene	5.34 x 10 ^{0a}	3.00 x 10 ^{-1c}	5.34 x 10 ^{-8d}	7.23 ^f
Dichlorodifluoromethane	1.20 x 10 ^{-2a}	3.00 x 10 ^{-1c}	ND	2.16 ^f
Dioxins	1.40 x 10 ^{0a}	3.00 x 10 ^{-2g}	ND	7.02 ^f
Furans	1.40 x 10 ^{0a}	3.00 x 10 ^{-2g}	ND	5.82 ^f
Fluoranthene	4.30 x 10 ^{-1c}	3.00 x 10 ^{-1c}	6.50 x 10 ^{-6f}	5.33 ^f
Fluorene	ND	3.00 x 10 ^{-1c}	6.42 x 10 ^{-5f}	4.18 ^f
4-Nitroaniline	ND	3.00 x 10 ^{-1c}	ND	ND
4-Nitrophenol	6.00 x 10 ^{-3a}	3.00 x 10 ^{-1c}	1.91 x 10 ^{0f}	ND
Naphthalene	6.90 x 10 ^{-2a}	3.00 x 10 ^{-1c}	ND	3.36 ^f
Pentachlorophenol	6.50 x 10 ^{-1a}	3.00 x 10 ^{-1c}	2.75 x 10 ^{-6f}	5.00 ^f
Phenanthrene	2.70 x 10 ^{-1c}	3.00 x 10 ^{-1c}	3.93 x 10 ^{-5f}	4.46 ^f
Pyrene	5.30 x 10 ^{-1a}	3.00 x 10 ^{-1c}	5.10 x 10 ^{-6f}	5.18 ^f
Tributyl phosphate	3.13 x 10 ^{-2a}	3.00 x 10 ^{-1c}	ND	4.00 ^f
Pesticide/PCBs				
Aroclor-1016	1.30 x 10 ^{0e}	3.00 x 10 ^{-1c}	1.07 x 10 ^{-3f}	4.38 ^f
Aroclor-1221	1.30 x 10 ^{0e}	3.00 x 10 ^{-1c}	1.07 x 10 ^{-3f}	4.09 ^f
Aroclor-1242	1.80 x 10 ^{0e}	3.00 x 10 ^{-1c}	3.43 x 10 ^{-4f}	4.11 ^f
Aroclor-1248	1.80 x 10 ^{0e}	3.00 x 10 ^{-1c}	4.40 x 10 ^{-4f}	5.75 ^f
Aroclor-1254	1.00 x 10 ^{0e}	3.00 x 10 ^{-1c}	8.37 x 10 ^{-3f}	6.03 ^f

TABLE E.4-6
(Continued)

Constituent	Water Permeability Coefficient (cm/hr)	Soil Absorption Coefficient (unitless)	Henry's Law Constant (atm-m ³ /mol)	Log K _{ow}
Aroclor-1260	1.00 x 10 ^{0e}	3.00 x 10 ^{-1c}	3.36 x 10 ^{-4f}	6.11 ^f
4,4'-DDT	6.00 x 10 ^{-1e}	3.00 x 10 ^{-1c}	3.89 x 10 ^{-5f}	6.19 ^f

^aEPA, 1992d, the default value for inorganics is 1×10^{-3} , the experimental value for cadmium. Organic K_ps were estimated using the regression equation: $\text{Log } K_p = -2.72 + 0.71 \log K_{ow} - 0.0061 \text{ MW}$.

^bWester et al. (1991).

^cEPA 1993d, Memorandum from J. Dollarhide ECAO to P. VanLeeuwen Region V, 7/21/93, including Attachments 1-6.

^dSuperfund Public Health Evaluation Manual, October 1986, (SPHEM).

^eEPA, 1992h.

^fEPA, Werl Treatability Database, 1991.

^gATSDR, 1989, "Toxicological Profile for 2,3,7,8-Tetrachlorodibenzo-p-dioxin", Atlanta, GA.

^hND - Not determined.

E.5.0 HEALTH RISK CHARACTERIZATION

4787

This section provides a characterization of the potential human health risks associated with the potential exposure to chemicals and radionuclides originating in Operable Unit 1. Section E.5.1 presents the methods used to estimate the type and magnitude of health risks associated with radionuclide and chemical exposures, and Section E.5.2 presents the results of the risk assessment calculations for measured and modeled current concentrations of constituents in the Operable Unit 1 source areas. Section E.5.3 presents the results of the risk assessment calculations for estimated future concentrations of radionuclides and chemicals in the Operable Unit 1 source areas. Section E.5.4 contains a summary of the results.

E.5.1 RISK CHARACTERIZATION METHODOLOGY

Potential human health risks resulting from exposure to radionuclides and nonradioactive chemicals are estimated using methods established by the EPA, including, but not limited to, Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (EPA 1989a). Methods described by the EPA are health-protective and are likely to overestimate rather than underestimate risk. The methodologies used to assess radiological and chemical risks differ slightly.

EPA's CERCLA methodology, which is set forth in recent guidance such as the Risk Assessment Guidance for Superfund and its supporting documents, uses specific algorithms to calculate human health risks as a function of chemical concentration, human exposure parameters, and toxicity. The product of the chemical concentration and the exposure parameters results in determination of an intake, as shown in Attachment E.III.

E.5.1.1 Radiocarcinogenic Risks

Procedures for estimating the incremental lifetime cancer risks (ILCRs) as a result of cumulative, lifetime exposure (i.e., a 70-year average life span) to a radionuclide are discussed in the following sections.

E.5.1.1.1 Methodology for Internal Radiation Exposures

Risk characterization for internal exposures to radionuclides (e.g., intake via inhalation or ingestion) is calculated as follows:

$$ILCR_i = (Intake_i)(CSF_i) \quad (E.5-1)$$

where

ILCR_i = Incremental Lifetime Cancer Risk, expressed as a unitless probability
intake_i = Intake of radionuclide "i" (pCi)
CSF_i = Cancer Slope Factor of radionuclide "i" (pCi⁻¹)

4787

E.5.1.1.2 Methodology for External Radiation Exposures

Risk characterization for external exposure to gamma-emitting radionuclides in contaminated surface soil is calculated as follows:

$$ILCR_{ei} = (Intake_{exti})(CSF_{exti}) \quad (E.5-2)$$

where

- $ILCR_{ei}$ = Incremental Lifetime Cancer Risk, expressed as a unitless probability
- $Intake_{exti}$ = Intake of radionuclide "i" (pCi-y/g)
- CSF_{exti} = Cancer Slope Factor (external) of radionuclide "i" (pCi-y/g)⁻¹

External intakes account for contributions to the total risk from decay products (radioactive progeny). For example, the ILCR due to continuous, lifetime external exposure to soil contaminated with Ra-226 and its progeny, assuming secular equilibrium (all members of the decay series disintegrate by the same number of atoms per unit of time), includes the risks contributed by Ra-226 and each decay product that emits photon radiation such as Lead-214 (Pb-214) and Bismuth-214 (Bi-214).

E.5.1.2 Chemical Risks

Risks from hazardous chemicals are calculated for either carcinogenic or noncarcinogenic effects. In addition, some carcinogenic chemicals may also present a toxic (noncarcinogenic) hazard. Potential impacts from these chemicals are characterized for both types of health effects.

E.5.1.2.1 Methodology for Carcinogens

Risks attributed to exposure to chemical carcinogens are estimated as the probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. At low doses, the ILCR is determined as follows (EPA 1989a):

$$ILCR_i = (Intake_i)(CSF_i) \quad (E.5-3)$$

where

- $ILCR$ = Incremental Lifetime Cancer Risk, expressed as a unitless probability
- $Intake_i$ = Intake of chemical "i" (mg/kg/day)
- CSF_i = Cancer Slope Factor of chemical "i" (mg/kg/day)⁻¹

Risks below 1×10^{-6} (a risk less than 1 in 1 million) are generally considered to be acceptable by the EPA, and risks greater than 1×10^{-4} (1 in 10,000) are generally considered to be unacceptable by the agency.

When carcinogenic risks exceeds 1×10^{-2} using the above methodology, EPA (1989a) specifies that the one-hit model be used as follows:

0648

$$\text{Risk} = 1 - \exp^{-(\text{intake})(\text{CSFi})} \quad (\text{E.5-4})$$

E.5.1.2.2 Methodology for Noncarcinogens

The risks associated with the effects of noncarcinogenic hazardous chemicals are evaluated by comparing an exposure level or intake to an RfD. The ratio of the intake to the RfD is called the Hazard Quotient (HQ) (EPA 1989a) and is defined as:

$$\text{HQ} = \text{Intake}_i / \text{RfD}_i \quad (\text{E.5-5})$$

where

HQ	=	Hazard Quotient (unitless)
Intake _i	=	Intake of chemical "i" (mg/kg/day)
RfD _i	=	Reference dose of chemical "i" (mg/kg/day)

Long-term chemical exposures are evaluated using chronic RfD values, however, exposures for the home builder are evaluated using subchronic RfDs where available.

This approach is different from the probabilistic approach used to evaluate carcinogens. An HQ of 0.01 does not imply a 1 in 100 chance of an adverse effect, but indicates only that the estimated intake is 100 times less than the reference dose. An HQ of unity (1) indicates that the intake is equal to the RfD. If the HQ is greater than 1, exposure to that chemical at detected concentrations may be expected to cause adverse health effects.

E.5.1.3 Exposures to Multiple Constituents

Environmental media at Operable Unit 1 contain multiple chemicals and radioactive constituents. For a given pathway with simultaneous exposure of a receptor to several carcinogens, the following equation is used to sum cancer risks:

$$\text{Risk}_p = \text{Risk}(\text{chem}_1) + \text{Risk}(\text{chem}_2) + \dots \text{Risk}(\text{chem}_i) \quad (\text{E.5-6})$$

where

Risk _p	=	Total pathway risk of cancer incidence
Risk(chem _i)	=	Individual carcinogenic chemical risk

In the case of simultaneous exposure of a receptor to several noncarcinogens, a Hazard Index (HI) is calculated as the sum of the HQs by:

$$\text{HI} = \text{HQ}_1 + \text{HQ}_2 + \dots + \text{HQ}_i \quad (\text{E.5-7})$$

For simplicity's sake, target organ effects are not considered for OU1. Target organ effects become critical when the Hazard Index exceeds unity. At that time, EPA guidance (EPA 1989a) suggests separating the Hazard Index by target organ to refine risk estimates. This becomes less critical when

4787
individual chemicals result in Hazard Quotients of greater than 1.0. Under those circumstances, it is possible that any of the chemicals with Hazard Quotients greater than 1.0 could result in toxic health effects. In most cases at OU1, when the Hazard Index exceeds 1.0, one or more individual chemicals have Hazard Quotients that also exceed 1.0.

E.5.1.4 Multiple Pathways

Multiple exposure pathways are assumed for the hypothetical receptors evaluated in this assessment. The risks from various exposure pathways are additive to a receptor experiencing more than one of them. For example, the risks from drinking water and the risks from inhalation incurred by the same individual are summed to determine the total risk to that receptor.

E.5.2 RISK ESTIMATES FOR CURRENT SITE CONDITIONS

As described in Section E.3.0, several hypothetical receptor populations are evaluated in the risk assessment for the current land use scenario. All exposures addressed in this section are based on the current source term (i.e., waste pit covers are intact, no surface runoff, etc.). Two receptors, the trespassing child and the on-property visitor, are assumed to incur exposures while within the operable unit boundaries.

Two additional hypothetical receptors are considered to be off-property receptors because they are potentially exposed to constituents that migrate off-property. These receptors are a resident adult and a user of beef and dairy products. A "composite" resident is also considered, which assumes a person is exposed to both migrating constituents as well as to food produced on-property, and that the individual trespassed as a child.

This section and all following sections are organized around general risk summary tables that present total radio- and chemocarcinogenic risk and Hazard Indices by exposure route for each receptor. All detailed (i.e., chemical-specific) information is contained in Attachment E.IV.

E.5.2.1 On-Property Exposures of Off-Property Receptors

Two receptors were evaluated who may be expected to incur intermittent exposures to contaminants while on property. It should be noted that no one routinely visits the area as per the visitor scenario, and a trespassing child cannot gain access under current site security controls.

Air modeling was used to identify the point of maximum on-property risk. In brief, once the transport criteria were fixed and the source (soil) concentrations were input, the resulting air concentrations were combined with the composite radiological and chemical intake and dose-response factors to determine the grid location of maximum risk. In the case of onsite exposures, this point was the 0,0 coordinate, which is located in the center of the Burn Pit, as shown in Figure E.3-4. All risks discussed for the

onsite air concentrations under the current conditions are based on the predicted air concentrations at that point, for whatever time frame is specified for a particular scenario/receptor.

E.5.2.1.1 Trespassing Child

The hypothetical trespassing child is assumed to receive exposures while wandering randomly through the study area, and is evaluated to explore potential risks to a subpopulation of potential concern. This receptor is assumed to be an older child, aged 6 through 17 years old. A more detailed description of this receptor and the parameter values used in calculating risks are presented in Section E.3.5 of this report. Chemical-specific risk estimates and hazard quotients are presented in Tables E.IV-1 and E.IV-2, and are summarized by pathway and media in Tables E.5-1 and E.5-2.

Radionuclides

The measured and modeled concentrations of radionuclides in surface soil and air produce a total calculated risk of 5×10^{-5} , as shown in Table E.5-1. Air (inhalation exposures only), penetrating radiation from buried waste pit material, and external gamma exposure to radionuclides in surface soil contribute roughly equal portions of the total risk. Uranium and thorium isotopes (in equilibrium with their short-lived daughters) and Rn-222 are the primary radionuclides of concern in the air and account for almost 100 percent of the total risk. Uranium, thorium, and radium isotopes are the primary components of the external exposure risk.

Chemical Carcinogens

If exposed to the concentrations of contaminants currently found in surface soil or predicted to exist in air, the trespassing child would incur a total risk of 2×10^{-5} . This total risk includes 4×10^{-7} from the inhalation of fugitive dust containing chromium and other metals, and a risk of about 10^{-5} from dermal contact and incidental ingestion of soil containing Aroclor-1254 and beryllium. Unlike the radionuclides, dermal contact with soil presents essentially 100 percent of the total risk.

Chemical Toxicants

The current measured concentrations of noncarcinogenic chemicals found in the surface soil and predicted concentrations of these contaminants in air produce calculated Hazard Indices of about 0.1 from inhalation of fugitive dust and 0.1 from dermal contact with soil, for a total Hazard Index of 0.2 from all pathways. Hazard Indices are summarized in Table E.5-2. Inhalation of cobalt in dust and dermal contact with soil containing uranium and antimony are the primary contributors to the total Hazard Index for this receptor. The results indicate that exposure to noncarcinogenic compounds by a trespassing child would be unlikely to result in any adverse (toxic) health effects.

E.5.2.1.2 Visitor

The hypothetical visitor is an adult who is expected to be exposed on a routine basis over a period of 25 years. As stated in Section E.3 and the Risk Assessment Work Plan Addendum (DOE 1992a), this receptor is not expected to come into direct contact with the soil, and hence is exposed only via inhalation of fugitive dust and external gamma radiation from both buried waste pit material and surface soil. The exposure input parameters used in evaluating this receptor were presented in Table E.3-16. Detailed chemical-specific risk estimates and hazard quotients are presented in Tables E.IV-3 and E.IV-4, and are also summarized in Tables E.5-1 and E.5-2.

Radionuclides

Inhalation of fugitive dust, penetrating radiation from buried waste pit materials, and external exposure to radionuclides in soil, again, are the primary exposure routes of concern for this receptor. Uranium and thorium isotopes and Rn-222 are the primary contributors to the inhalation risk, and uranium, thorium, and radium isotopes are most significant in external gamma exposures. The total risk from radionuclides for this receptor are 3×10^{-4} .

Chemical Carcinogens

The inhalation risk for the visitor under the defined exposure scenario is 3×10^{-6} . This risk is due primarily to the presence of chromium at a predicted concentration of 4×10^{-6} mg/m³ in the air on-property. Arsenic, beryllium, cadmium, and nickel also contribute to the risk.

Chemical Toxicants

Most of the metals found in the soil are not toxic via inhalation, and direct contact is not considered for this receptor, therefore risks are low. As with the trespassing child, cobalt in fugitive dust is the primary driver of the Hazard Index for inhalation. The estimated HI is 0.5 for this route of exposure. However, this Hazard Index is below unity, and therefore the onset of toxic effects is unlikely for this receptor.

E.5.2.2 Off-Property Exposures

Incremental lifetime cancer risks and Hazard Indices were also calculated for those persons potentially affected by the chemicals and radionuclides present at the FEMP even though those persons are not physically located on the property. The hypothetical receptors considered are the off-property resident adult and the off-property resident who uses animal products raised within the operable unit's boundaries. Air modeling was used to identify the point of maximum risk off-property, which in this case was a point at the fenceline approximately 450 meters west and 150 meters south of the center of the Burn Pit, as shown in Figure E.3-4.

0652

E.5.2.2.1 Off-Property Resident Adult Farmer

At the current time, no homes are located at the point of maximum risk via the air exposure pathways. However, a hypothetical receptor was developed based on the assumption that he would be subject to indirect (air) exposures from the property for a period of 70 years. A more detailed description of this receptor and the parameter values used in calculating risks are presented in Section E.3.5 of this report. For the current scenarios, this receptor's risks are also summarized on Tables E.5-1 and E.5-2. Detailed, chemical-specific risks and hazard quotients are presented in Tables E.IV-5 and E.IV-6.

Radionuclides

The hypothetical off-property resident who is exposed to the predicted concentrations of radionuclides from air incurs a total calculated risk of 6×10^{-5} , as shown in Table E.5-1. Table E.IV-13 indicates that these risks are primarily associated with the presence of thorium and uranium isotopes and Rn-222. Risks from inhalation constitute almost 100 percent of the total air pathway risks.

Chemical Carcinogens

Exposure of the off-property resident adult is also considered for the predicted air concentrations of chemicals originating in the surface soil at the FEMP. Multiple exposure routes are considered, such as inhalation of dust and ingestion of foodstuffs affected by dust. The risk from all the food pathways in combination exceed the risk incurred via inhalation. A hypothetical receptor is expected to experience a total carcinogenic risk of 3×10^{-6} , which is more than an order of magnitude below the risks attributable to the radionuclides.

There are two major contributors to the total chemical carcinogenic risk. The first is Aroclor-1254, which presents the primary component of the food pathways risk, and chromium, which results in the highest risk via inhalation of fugitive dust.

Chemical Toxicants

A number of metals were found in the surface soils, and are subject to off-property transport via fugitive dust emissions. While many of these metals are not toxic via inhalation, the fallout on foodstuffs can contribute to the total Hazard Index. As shown in Table E.5-2, the total Hazard Index for this receptor is 0.07.

E.5.2.2.2 Off-Property User of Meat and Dairy Products

The final receptor considered under the current source term/land use configuration is an off-property adult who routinely (over a period of 70 years) ingests meat and dairy products from cows grazed and watered in the Operable Unit 1 area. This scenario is based on the current surface soil and surface water concentrations, and uses the exposure input parameters presented in Table E.3-16. This receptor could only be exposed should land use controls be discontinued. The risks are summarized in Tables

E.5-1 (carcinogenic risks) and E.5-2 (Hazard Indices). Tables E.IV-7 and E.IV-8 present the detailed risks and hazard quotients for each chemical, exposure route, and medium.

Radionuclides

The total incremental lifetime cancer risk incurred by the off-property user of meat and dairy products produced on site is 6×10^{-4} for the radionuclides. Grazing of cows and the subsequent ingestion of dairy products is the route that produces the maximum risk. This exposure scenario's risks are driven by the uranium isotopes, Tc-99, Sr-90, and Cs-137. With the exception of the uranium isotopes, which were found at high activities, Tc-99, Sr-90, and Cs-137 are highly mobile in the environment and readily transfer from soil to plant material.

Chemical Carcinogens

For this scenario and receptor, biotransfer from soil to plant material and thence to meat or milk controls the total carcinogenic risks. The total risk to the off-property resident exposed in this manner is about 2×10^{-3} , and is almost solely attributable to soil biotransfer to meat and milk. Aroclor-1254 is the primary chemical carcinogen for this exposure scenario, followed by arsenic. Arsenic in the surface waters (Waste Pits 5 and 6 and the Clearwell) at a weighted average concentration of 0.003 mg/L contributes a risk of 7×10^{-6} . The fact that this concentration is well below the drinking water standard emphasizes the conservative nature of the models and assumptions used in this assessment. Note also that the concentration of arsenic in the surface soil was only 4.9 mg/kg, and resulted in a food pathway risk of 5×10^{-5} .

Chemical Toxicants

The off-property resident adult incurs a Hazard Index of 11 via all routes of exposure. The food pathways originating with soil and the ingestion of meat from cows watered on the property all result in Hazard Indices greater than 1.0. Silver, zinc, and antimony all have Hazard Indices above or approaching unity for the pathways originating in soil, while zinc is most significant for the water pathways. These Hazard Indices are summarized in Table E.5-2.

E.5.2.2.3 Composite Off-Property Resident

It is conceivable that a local resident could not only live downwind of the waste pits, but could also ingest locally produced meat or dairy products and have trespassed on the site as a child. In this unlikely case, the total risks incurred by this receptor would be the total risks for three of the receptors presented above. When exposures overlap, the more conservative value is considered. For example, both the off-property resident adult and the off-property user of meat and dairy products consume animal products at the same rate, therefore only the activity giving the higher exposure (consumption of meat and dairy products grown on-site) is counted toward the total exposure to the composite off-property resident.

0654

The total radiological risk would approach 10^{-3} (7×10^{-4}). This accounts for direct radiation exposures and soil ingestion/dermal contact as a trespassing child (4×10^{-5}), inhalation of dust and ingestion of vegetables and fruits affected by aerial deposition (5×10^{-5}), and ingestion of meat and dairy products produced on property (6×10^{-4}). The total chemical carcinogenic risk for this composite receptor would be 2×10^{-3} for the same routes of exposure. For both sets of contaminants, the risk is driven by the soil biotransfer to the food chain (meat), followed by inhalation. Of the radionuclides, Tc-99 in the soil is most significant, and Aroclor-1254 is the most significant risk driver for the chemical carcinogens.

The composite HI for this receptor is 11 for all pathways. Again, it is the biotransfer from soil to vegetation and into the food chain that drives this risk. Zinc, silver, and antimony are the primary noncarcinogenic analytes in this exposure scenario.

E.5.2.3 Summary of Health Effects Under the Current Land Use Scenarios

This section summarizes the calculated health risks for the current land use scenarios evaluated by contaminant and pathway. Only the RME receptors for both onsite and offsite exposures are addressed. Because no food is currently produced at Operable Unit 1, the RME individual for the off-property exposures in this discussion is considered to be the local resident living downwind of the waste pits. The visitor is the RME receptor for the onsite exposures. Table E.5-3 contains a summary of the results for these receptors.

In general, the risk assessment has shown that organic chemicals are not a major concern at this site under current land use/source term conditions. The uranium, thorium, and radium isotopes and radon control exposures for both the on- and off-property maximally exposed individuals. U-238 is the major contributor to the radiocarcinogenic air risks, and Th-228 drives the external exposures.

When food chain exposure pathways are considered, the primary contaminants change. Tc-99, Cs-137, and Sr-90 become significant contributors to the total risk. However, given the current configuration of the operable unit and the access controls in place, raising of food on property and having an individual whose sole lifetime intake of meat and milk is from cows grazed on-property is highly unlikely.

Arsenic, chromium, cadmium, and Aroclor-1254, which were found in the surface soil at UCL concentrations of 4.9, 14.3, 5.8, and 1.4 mg/kg, respectively, represent the majority of the chemical carcinogenic risks at this facility. The high risks associated with these concentrations illustrates the conservative nature of the scenario assumptions and exposure parameters used.

E.5.3 RISK ESTIMATES FOR FUTURE SITE CONDITIONS

If the government were to release control of the FEMP property, current land use could change. For example, a person could at that time build a house and reside on the property with a family. Several receptors are evaluated to determine the risks associated with future land uses. Since the maximum exposures for these receptors occur in the future when waste pit material is exposed and runoff control does not exist, the probability of adverse human health effects is greater than with the current site configuration. Receptors evaluated in this baseline risk assessment are the RME resident adult farmer, CT resident adult farmer, RME resident child, and the home builder. With the exception of the home builder, these receptors live on the Operable Unit 1 study area.

A number of off-property receptors were also evaluated for the future site conditions and current land use. These scenarios assume that government or industrial ownership continues but that maintenance ceases, that land uses remain the same, that waste pit covers erode, etc. These receptors are the off-property RME resident adult, the Great Miami River user, and an off-property user of meat and dairy products. In addition, a trespassing child was considered for circumstances where access controls no longer exist.

E.5.3.1 On-Property Exposures of Off-Property Residents

As under the current site conditions, it is possible that an older child could trespass on the property over a period of 12 years. This receptor could be exposed to site-related contaminants via inhalation of fugitive dust and radon, via penetrating gamma radiation from buried waste pit material, and via direct contact with surface soil, exposed waste pit material, and sediment in Paddys Run that originated as soil within the Operable Unit 1 boundaries. ILCRs and hazard quotients for this receptor are summarized in Table E.5-4, and the detailed calculations are contained in Tables E.IV-9 and E.IV-10.

Radionuclides

Exposures to fugitive dust emissions and external exposure from exposed waste pit material and surface soil result in roughly equal risks (2×10^{-4} and 3×10^{-4}), and account for almost 100 percent of the total radiocarcinogenic risk (5×10^{-4}) for this receptor. The primary contributors to this risk are Rn-222, Th-230, and the uranium isotopes found in the exposed waste pit materials from Waste Pits 3, 5, and 6. Other routes of exposure such as sediment or soil ingestion and external exposure to sediment result in risks one or more orders of magnitude lower.

Chemical Carcinogens

The total chemical carcinogenic risk for the trespassing child is 2×10^{-4} . Inhalation of fugitive dust and dermal contact with soil result in the greatest individual pathway risks (1×10^{-4} and 3×10^{-5} , respectively) for this receptor. These risks are driven by the presence of PCBs, arsenic, beryllium, and chromium in the soil. Organic compounds such as PAHs and dioxins result in risks one or more

orders of magnitude lower than the metals. For example, the total risk for all PAHs via soil ingestion and dermal contact is 6×10^{-9} and all chlorinated dioxins and furans result in a total soil pathway risk of 4×10^{-8} .

Chemical Toxicants

Dermal contact with soil contributes half (2) of the overall Hazard Index (4) for this receptor. Uranium, vanadium, and arsenic dominate the dermal contact Hazard Indices. Inhalation of fugitive dust and ingestion of soil have similar Hazard Indices (0.8 and 0.9, respectively).

E.5.3.2 Off-Property Exposures

Given the future site configuration and existing land uses in the vicinity of the FEMP, several off-property receptors could be exposed to contaminants that originate on property. These receptors are exposed only via those media that are transported off property, such as air, surface water, or groundwater.

The groundwater modeling exercise determined the location of the maximum carcinogenic risk in much the same manner as that described earlier for the air modeling. A grid was established, and once the contaminant plume migration was predicted for each grid node, the composite intakes and risks were applied to the predicted concentrations of each modeled constituent at each node. Once the point of maximum risk was determined, the concentrations of all contaminants at that point were evaluated.

In this case, the point of maximum off-property risk via groundwater exposure is located east of the fenceline. Modeled constituents are estimated to reach a maximum total risk at that location in approximately 680 years. The point of maximum on-property risk is located just downgradient of Waste Pit 4, and the maximum concentrations leaching from the waste pits is expected in 630 years. These receptor locations were shown in Figure E.3-4.

E.5.3.2.1 Off-Property Resident Adult Farmer

This receptor has the same characteristics as the off-property resident evaluated under the current source term. The only difference is that this person could now experience additional exposures related to changes in the site configuration, such as erosion of soil caps over the waste pit material and increased leaching. The cancer risks and hazard quotients for this receptor are summarized in Table E.5-5, and the detailed chemical-specific information is contained in Tables E.IV-11 and E.IV-12. Total carcinogenic risks for all groundwater routes of exposure are shown in Figure E.5-1.

Radionuclides

The total radiocarcinogenic risk experienced by this hypothetical receptor is estimated at 2×10^{-3} . The most significant routes of exposure for the off-property resident are the inhalation of fugitive dust ($9 \times$

10^{-4}) and ingestion of drinking water (5×10^{-4}). The risk associated with inhalation of uranium and thorium isotopes and Rn-222 is about 99 percent of the total. U-238 contributes more than 80 percent of the drinking water ingestion risk and the total groundwater risk for all pathways (including food ingestion). However, note that this total risk is an overestimation, given that the predicted locations of maximum risk via air and groundwater are not the same (Figure E.3-4).

Chemical Carcinogens

None of the modeled groundwater chemical constituents that reach the fenceline are carcinogenic via ingestion and therefore carcinogenic risks via the groundwater pathway are zero. However, arsenic and nickel are carcinogenic via inhalation but metals do not volatilize during showering. The total chemical carcinogenic risk for the off-property RME resident is 4×10^{-3} , and inhalation accounts for about 75 percent of the total. Other groups of compounds predicted to be found in fugitive dust emissions such as PAHs and dioxins and furans contribute a total risk for all pathways (by class of compounds) of 8×10^{-7} and 1×10^{-5} , respectively, which are two orders of magnitude less than the risk attributable to arsenic and nickel.

Chemical Toxicants

As shown in Table E.5-5, the total Hazard Index for all exposure routes for the off-property RME resident is 60. Ingestion of vegetables and fruit affected by airborne contaminants contributes two thirds of the total risk. Uranium, nickel, and arsenic are the major drivers of the Hazard Index.

E.5.3.2.2 Great Miami River User

This hypothetical adult receptor is assumed to live adjacent to the Great Miami River and use untreated river water for all domestic uses, as well as for swimming and as a source of fish, over a period of 70 years. The Great Miami River user is evaluated to explore the risks to an off-property subpopulation of concern. A more detailed description of this receptor and the input parameters used to calculate risks is contained in Section E.3.

Only radionuclides are predicted to reach the river, based on the modeling conducted for the facility. Nuclide-specific risks are contained in Table E.IV-13, and are summarized in Table E.5-7.

Radionuclides

The total incremental cancer risk incurred by this hypothetical receptor is 3×10^{-7} , which is within the range generally considered to be acceptable. Of all the pathways evaluated, routine ingestion of the river water as a potable water source results in the highest risk (2×10^{-7}). U-238, which is predicted to reach the river at a concentration of 0.103 pCi/L, contributes about 80 percent of this risk. U-234 and Tc-99 make up essentially all of the remaining risk.

0658

The second most significant exposure pathway for this receptor is the ingestion of vegetables and fruits irrigated with river water. Under this hypothetical scenario, Tc-99 (by virtue of its efficient biotransfer) and U-238 and U-234 (by virtue of their higher concentrations) contribute the majority of the risk.

E.5.3.2.3 Off-Property User of Meat and Dairy Products

This receptor was described in detail in Sections E.5.2.2.2 and E.3 of this report. The total carcinogenic risks and Hazard Indices experienced by this receptor are contained in Table E.5-8, and chemical-specific risks for each pathway/medium combination are contained in Tables E.IV-14 and E.IV-15.

Radionuclides

The total incremental lifetime cancer risk from radionuclides associated with the production of food on the Operable Unit 1 area is 6×10^{-4} . Ingestion of dairy products over a period of 70 years by this hypothetical off-property receptor results in a risk of 5×10^{-4} , due primarily to the efficient biotransfer of Tc-99 and Sr-90 from the soil to plants to milk, as well as to the higher concentrations of U-238 found in Waste Pits 3 and 6.

Chemical Carcinogens

As with the current land use/source term configuration, it is the ingestion of food products from cows grazed on property (versus livestock watering on property) that drive the risks. Ingestion of meat results in a total risk of 8×10^{-4} , and ingestion of milk has an associated risk of 7×10^{-4} . Aroclor-1254 and arsenic are the major components of the total risk for these pathways. Total risks associated with watering of cows on property are lower (7×10^{-7}), and are the result of the presence of arsenic and benzene in the onsite water-filled waste pits at weighted average concentrations of 0.002 mg/L and 0.008 mg/L, respectively. Once again, these results reflect the conservative nature of the assumptions made in the exposure models and the selection of input parameters.

Chemical Toxicants

The only analytes found in the soil and surface water samples that exhibit toxic effects in man are metals. The total Hazard Index from the food pathways originating in soil and surface water is 11. Grazing of cows in areas containing antimony, silver, and zinc can result in an unacceptable Hazard Index to the defined receptor.

E.5.3.2.4 Composite Off-Property Resident

A composite off-property receptor is also considered in this risk assessment. It is considered possible (however unlikely) that a local resident could trespass on the site as a child, live downwind or downgradient of the site as an adult, and regularly ingest meat or dairy products grown on property.

Radionuclides

The total radiological risks associated with these multiple exposures are 3×10^{-3} , and would therefore be considered as unacceptable. Uranium and thorium isotopes (for the direct contact scenarios) and Tc-99 and Sr-90 (for the food ingestion pathways) are the most significant contributors to the risk.

Chemical Carcinogens

Arsenic and Aroclor-1254 found in the soil drive the carcinogenic risks for this hypothetical composite receptor. The food pathways (ingestion of fruits and vegetables affected by dust from the site, ingestion of meat and dairy products from cows grazed on the site) cause the major portion of the risk. The total pathway risk for this receptor from carcinogenic chemicals also exceeds 10^{-3} (6×10^{-3}).

Chemical Toxicants

There are several metals that contribute to the Hazard Index of 75 for the composite off-property receptor. Antimony, zinc, and silver are significant, especially via the food ingestion pathways, ingestion of water, and dermal contact with soil and exposed waste pit material as a trespassing child.

E.5.3.3 On-Property Exposures

Once access controls are removed from the property, and control of the site passes from government hands, it is possible that a family could build a homestead and live and work on property. There are four receptors who could potentially be exposed under this hypothetical scenario. They are the RME resident adult and child, a CT adult, and a home-builder (e.g., construction worker). Each of these receptors was described in detail in Section E.3 of this report, along with the exposure input parameters that define their intakes and risks.

E.5.3.3.1 RME Resident Adult Farmer

This receptor is defined as an on-property resident farmer who spends his entire lifetime living and working on the Operable Unit 1 area. He receives direct exposures from a number of media by virtue of spending his life on property. The point of maximum exposure for this individual is considered to be in the vicinity of Waste Pit 4 and the Burn Pit. The total risks for this receptor are summarized in Table E.5-9 (carcinogenic risks) and E.5-10 (Hazard Indices), and chemical-specific risks and hazard quotients are contained in Tables E.IV-16 and E.IV-17.

Radionuclides

Disregarding the presence of existing contamination in the perched water beneath the waste pits, the total radionuclide risk for this receptor is 4×10^{-2} . Because the perched water is unlikely to provide a consistent water supply for routine domestic and agricultural uses, ingestion only was considered for this medium and is included for reference only. It is considered highly unlikely that a resident would have two wells. U-238 was found at high concentrations in the perched water (429,000 pCi/L), and is solely responsible for the observed risk (5×10^{-1}) in the perched water.

Inhalation of fugitive dust and radon and external exposure to radionuclides in surface soil and exposed waste pit material contribute about 75 percent of the total risk. Uranium and thorium isotopes and radon in the air, and radium and thorium isotopes in the soil/waste pit material are the major contributors to the risk. Ingestion of drinking water at the predicted time of maximum risk (630 years from now, determined as described earlier) would result in a risk of 7×10^{-3} . U-238 is the major contributor to the ingestion risk.

Other pathways and exposures are much smaller than these calculated risks. For example, risks associated with exposures to radon entering a home from the soil beneath it are about 1×10^{-7} .

Chemical Carcinogens

The total risk associated with exposure to chemical carcinogens (5×10^{-2}) is due primarily to various exposures to groundwater containing carcinogenic metals such as arsenic, and the ingestion of vegetables and fruits affected by air emissions from on-property sources. The air pathway risks are driven by the presence of Aroclor-1254 and arsenic in the soil.

The risk associated with ingestion of water from the perched aquifer is 1×10^{-1} . This risk is almost wholly attributable to the presence of arsenic in a single groundwater sample at a concentration of 0.582 mg/L. This high concentration skewed the distribution, and the UCL on the mean exceeded the maximum detection, therefore the maximum concentration was considered in the risk assessment.

Chemical Toxicants

The total Hazard Index for the on-property RME resident is 670. While the numbers should not be interpreted as a probability, it can be said that ingestion of fruits and vegetables affected by particulate deposition represents the most significant portion of this total (Hazard Index = 280). Groundwater ingestion (Hazard Index = 200) is also likely to result in adverse (toxic) health effects. Uranium, antimony, arsenic, and manganese are the major contributors to the total Hazard Index for groundwater exposures.

Ingestion of water from the perched aquifer would result in a Hazard Index of 6000 for the adult resident. Uranium, thallium, and molybdenum are contributors to the Hazard Index.

E.5.3.3.2 CT Resident Adult Farmer

This hypothetical receptor is defined as residing on the Operable Unit 1 study area for a period of 9 years, with all exposure routes considered using the parameters presented in Table E.3-17. Although this receptor is similar to the RME resident adult discussed in the preceding section, parameter values have been selected to evaluate risks that are closer to the expected average values.

As suggested by EPA guidance (EPA 1992d), the resident CT adult is included in this assessment because calculated risks to this receptor provide a useful perspective on the uncertainty involved with exposure parameters used in calculating risks to the RME adult. While the central tendency evaluation calculates an incidence of health effects that is closer to the average or median incidence rate, it is important to note that many of the parameter values used exceed the median or average values. For example, the CT adult scenario in this analysis uses the upper 95 percent confidence interval on the mean as the exposure concentration. Thus the results presented for this receptor are not true average or median risks.

The risks for this receptor are also presented in Tables E.5-9 and E.5-10. Chemical-specific information on risks and individual pathways is contained in Tables E.IV-18 and E.IV-19.

Radionuclides

The overall risk from radionuclides for the CT receptor (6×10^{-3}) is about one-third that calculated for the RME receptor (3×10^{-2}). The primary sources of risk (i.e., pathways, media, and contaminants) follow approximately the same distribution.

Chemical Carcinogens

Calculated incremental lifetime cancer risks from chemical exposure for the CT resident adult total 4×10^{-3} , without consideration of ingestion of water from the perched aquifer. Again, the carcinogenic metals drive the risks, especially via ingestion of drinking water and ingestion of fruits and vegetables.

Ingestion of surface soil while working outdoors and ingestion of vegetables and fruits affected by air emissions from the source areas are also major components of the total risk.

Chemical Toxicants

The toxic effects due to on-property exposures via food ingestion pathways followed closely by groundwater ingestion dominate the total Hazard Index (340) for this receptor. Ingestion of drinking water and ingestion of food crops affected by aerial deposition are the primary components of this HI. Again, the toxic metals drive this risk, particularly arsenic and uranium.

E.5.3.3.3 RME Resident Child

This hypothetical child receptor is assumed to reside within the Operable Unit 1 study area for a period of 6 years. A more detailed description of this receptor and the parameter values used in calculating risks are presented in Section E.3.5 of this report. This receptor is evaluated to assess the impacts of chemicals on the critical subpopulation of children assumed to reside within the operable unit.

The carcinogenic risks for this receptor are summarized in Table E.5-8, and the Hazard Indices are summarized in Table E.5-9. Detailed backup for these results is contained in Tables E.IV-20 and E.IV-21.

Radionuclides

If the risks associated with ingestion of the perched water are discounted, the total radiocarcinogenic risk for the RME child receptor is estimated at 4×10^{-3} , which is an order of magnitude less than that predicted for the RME resident adult receptor. External exposure to exposed waste pit material and ingestion of contaminated groundwater together present about 80 percent of the total risk. Uranium, thorium, and radium isotopes are the primary constituents of this risk.

Chemical Carcinogens

Table E.5-9 indicates that the total chemical carcinogenic risks from all evaluated pathways is 2×10^{-2} . Ingestion of drinking water from the Great Miami aquifer and ingestion of fruits and vegetables irrigated with groundwater contribute about half of the total risk. Metals are the primary carcinogenic constituents.

Another 25 percent of the total risk is caused by direct exposures to surface soil and exposed waste pit material. Arsenic, beryllium, and other carcinogenic metals contribute much of the risk, followed by PAHs and the dioxins and furans.

Chemical Toxicants

The total Hazard Index for the RME child is 3100, as shown on Table E.5-10. The results of the risk assessment indicate that the food pathways play a major role in the risk, both via air pathways and groundwater pathways. In addition, ingestion of groundwater contributes heavily to the total. Uranium in soil and exposed waste pit material and groundwater is one of the major toxicants acting on potential child receptors at this facility.

Concentrations of lead in soil at Operable Unit 1 were compared to interim soil cleanup levels of 500 to 1000 ppm, which is recommended for use at Superfund sites where current or predicted land use is residential (EPA 1989k). The area-weighted average lead concentration of 116 ppm for Operable Unit 1 soils is below this recommended range, indicating that lead levels are not expected to pose a significant health hazard to sensitive receptors, including children.

E.5.3.3.4 Home Builder

The home builder spends 50 days in one year on the property while building a house. A more detailed description of this receptor and the parameter values used in calculating risks are presented in Section 3.3 of this report. This receptor is evaluated to assess the impacts of chemicals on anyone building a home within the operable unit. Health impacts from this activity may be considered by

4787

themselves or in combination with other RME receptor activities such as the on- or off-property RME adult or the trespassing child. However, given the fact that these total risks are one or more orders of magnitude lower than the risks presented for the future residents, they would have little impact on the overall risk.

This receptor is assumed to be exposed only to material in Pit 4. Only ingestion and dermal contact with the soil and inhalation of fugitive dust emissions were considered for this receptor. The risks are summarized in Tables E.5-9 and E.5-10, and details are presented in Tables E.IV-22 and E.IV-23.

Radionuclides

The total radiocarcinogenic risks experienced by this hypothetical receptor is 3×10^{-5} . This risk is due primarily to external exposure to Ra-226 and Th-232 in the soil, and to Th-230 and U-238 in the dust. These two exposure routes provide about 97 percent of the total risk to the homebuilder.

Chemical Carcinogens

Chemical carcinogenic risks for this receptor exceed the radiocarcinogenic risks. Ingestion of soil containing beryllium and various dioxins and furans contributes 98 percent of the total risk associated with direct soil contact. Inhalation of fugitive dust is fairly insignificant in the total risks.

Chemical Toxicants

The Hazard Index resulting from dermal exposure to and ingestion of soil while building a home (90) is primarily caused by the presence of uranium, antimony, and silver in the waste pit material. The inhalation Hazard Index (0.3) is primarily due to the predicted concentrations of arsenic and uranium in the air.

E.5.3.4 Summary of Health Effects Under Future Site Conditions

This section summarizes the calculated health effects for the future land use scenarios evaluated by chemical, by pathway, and by media. Emphasis is given to health effects which clearly dominate the assessment, and the discussion focuses on the off-property RME adult resident and the on-property RME resident adult farmer as being the maximally exposed individuals.

Table E.5-11 contains a summary of the total carcinogenic risks for these receptors. The off-property resident experiences his greatest exposures via the air emissions from the study area. When all pathways are considered, Th-230, U-238, and U-234 dominate the air radiocarcinogenic risks and nickel, arsenic, and chromium dominate the chemical carcinogenic risks.

Table E.5-12 presents a summary of the systemic risks for the maximally exposed individuals; the on-property RME resident child and the off-property RME resident adult farmer. Uranium toxicity clearly dominated the risk contributor with a small contribution by arsenic.

Groundwater exposures present a relatively minor component of the total risk (12 percent). No carcinogenic organics or metals are predicted to reach the property boundary at the time of maximum risk, as discussed earlier. However, a number of radionuclides are significant, with U-238 being the dominant nuclide.

Risks to the on-property RME resident are driven by the exposures to groundwater and surface soil and exposed waste pit contents. When all exposure routes are considered, including food ingestion, dermal contact, and ingestion, soil exposures cause 30 percent of the total risks and groundwater exposures cause 49 percent. Th-232, Ra-226, and U-238 are the major radiological constituents of potential concern, and arsenic is the chemical carcinogen that causes most of the chemical risks.

Air exposures, particularly the food pathways, also contribute to the total risks for the on-property RME resident. Th-230, U-238, and arsenic are the primary CPCs for the air pathways.

E.5.4 SUMMARY OF HEALTH RISK CHARACTERIZATION

The selection of CPCs for evaluation in this baseline risk assessment was a key step in the risk assessment process. Contaminants were selected on the basis of the history of site operations and an evaluation of characterization data with respect to the distribution and concentration of contaminants in the various media at the site and the potential contribution of individual contaminants to overall health effects. Confidence is high that the significant contaminants were identified because considerable information is available from the site characterization effort and few contaminants were eliminated as CPCs. The CPCs include 15 long-lived radionuclides and numerous chemicals consisting of metals, organic compounds, PAHs, PCBs, and dioxins and furans. Most of the radionuclides have short-lived daughters that are evaluated concurrently with the parent nuclides, unless specifically included. Low levels of radionuclides are spread throughout the soils of Operable Unit 1. Eight waste pits contain large inventories of waste with high concentrations of a number of chemicals and radionuclides.

Cancer induction is the only health effect considered for the radionuclides detected in Operable Unit 1, and many of the chemicals evaluated are potential carcinogens. This assessment indicates that metals (particularly arsenic) and radionuclides (particularly U-238, Th-232, and their short-lived progeny) are the contaminants contributing most significantly to risks.

Toxic effects other than carcinogenesis are considered for many of the metals and chemicals detected in Operable Unit 1. Several of the metals evaluated are present in concentrations which exceed the levels thought to produce toxic effects. Uranium, zinc, and antimony are most prevalent.

Health effects associated with exposures to lead could not be quantitatively assessed because of the unavailability of toxicity values. However, when the UCL concentration of lead in the soil is

4787

compared to the EPA's recommended values, the results indicated that lead in soil is not a major concern for the identified exposure routes and site configurations.

Receptors and exposure pathways were identified in this baseline risk assessment on the basis of site-specific considerations of current land use and reasonable projections of future land use that considered the time frame of this analysis. Confidence is high that the main exposure pathways and potential receptors have been identified and evaluated. Although additional receptors and activities could be identified, exposures would be similar to or less than those estimated for the specific receptors and pathways considered in this analysis. Standard (conservative) intake parameters were used for the assessment of the inhalation and ingestion pathways, and, although some uncertainty exists with respect to these values, this uncertainty is not expected to significantly affect the analysis.

The potential for health effects from exposure to site-related contaminants was estimated for on-property receptors and in adjacent off-property areas impacted by site releases. The on-property exposure points evaluated in this baseline risk assessment were operable unit soil, outdoor air and the waste pits. To focus the discussion, the magnitude of the total estimated carcinogenic risks and HIs are discussed relative to remedial action goals for an NPL site, as defined by the EPA (1989a, 1990c). These goals are an ILCR of 10^{-6} to 10^{-4} and an HI not to exceed 1 for toxic effects other than cancer.

Confidence in the quantitative results presented in the preceding sections (i.e., carcinogenic risks and toxic effects) depends on a number of factors. Perhaps the greatest single source of uncertainty in this assessment is the toxicity and slope factors used to convert exposures to risks. For Operable Unit 1 contaminants, the level of confidence ranged from very low (a factor of 100,000 for the dioxin slope factors) to high (a factor of 3 for the arsenic RfD). The high uncertainty factor of the dioxin group results in a lower (more conservative) slope factor; thus the risks from this group of chemicals may be overstated.

For the current source term and land use combinations, the receptors who experience the highest risks are the off-property user of meat and milk and the visitor. The visitor is exposed primarily via inhalation of fugitive dust, and in the case of the on-property visitor, radon emissions. Uranium and thorium isotopes cause most of the risk under the defined exposure scenarios. These risks within the 10^{-4} to 10^{-5} range. The off-property user of meat and milk are exposed to CPCs that biotransfer to meat and milk of livestock grazed on site. The CPCs are Tc-99, Sr-90, and U-238 radiological CPCs and Aroclor 1254 and arsenic for chemicals.

Under future land use conditions, the maximally exposed individual is the on-property RME resident. This receptor would experience a total risk in the 10^{-1} range for both radionuclides and chemical carcinogens combined. Inhalation of dust and radon, external exposure to surface soil and exposed waste pit material, and ingestion of drinking water/irrigation of fruit and vegetable crops with

contaminated groundwater drive the risks. Carcinogenic metals such as arsenic, toxic metals such as uranium, and various isotopes of uranium and thorium control the total risks.

1

2

2827

TABLE E.5-1

TOTAL CARCINOGENIC RISKS
CURRENT SOURCE TERM

Medium	Exposure Route	Trespassing Child		Visitor		Off-Property RME Resident		Off-Property User of Meat and Dairy Products	
		Radiological	Chemical	Radiological	Chemical	Radiological	Chemical	Radiological	Chemical
Air	Inhalation	1×10^{-5}	4×10^{-7}	1×10^{-4}	3×10^{-6}	6×10^{-5}	1×10^{-6}	NA	NA
	Ingestion of Vegetables and Fruit	NA ^a	NA	NA	NA	4×10^{-7}	7×10^{-7}	NA	NA
	Ingestion of Meat	NA	NA	NA	NA	7.4×10^{-9}	9×10^{-7}	NA	NA
	Ingestion of Dairy Products	NA	NA	NA	NA	6×10^{-8}	8×10^{-7}	NA	NA
Buried Pit Material	Penetrating Radiation	2×10^{-5}	NA	9×10^{-5}	NA	NA	NA	NA	NA
Surface Soil	Ingestion	2×10^{-7}	3×10^{-7}	NA	NA	NA	NA	NA	NA
	Dermal Contact	NA	2×10^{-5}	NA	NA	NA	NA	NA	NA
	External Exposure	2×10^{-5}	NA	8×10^{-4}	NA	NA	NA	NA	NA
	Ingestion of Meat	NA	NA	NA	NA	NA	NA	1×10^{-4}	7×10^{-4}
	Ingestion of Dairy Products	NA	NA	NA	NA	NA	NA	5×10^{-4}	8×10^{-4}
Surface Water	Ingestion of Meat	NA	NA	NA	NA	NA	NA	5×10^{-6}	6×10^{-6}
	Ingestion of Dairy Products	NA	NA	NA	NA	NA	NA	3×10^{-5}	7×10^{-7}
Subtotal		5×10^{-5}	2×10^{-5}	9×10^{-4}	3×10^{-6}	6×10^{-5}	3×10^{-6}	6×10^{-4}	2×10^{-3}
Total Carcinogenic Risk		7×10^{-5}		9×10^{-4}		6×10^{-5}		3×10^{-3}	

^aNA - Not applicable. Exposure route not evaluated.

E-5-22

0668

TABLE E.5-2

**TOTAL HAZARD INDICES
CURRENT SOURCE TERM**

Medium	Exposure Route	Trespassing Child	Visitor	Off-Property RME Resident	Off-Property User of Meat and Dairy Products
Air	Inhalation	0.1	0.5	0.06	NA
	Ingestion of vegetables and fruits	NA ^a	NA	0.005	NA
	Ingestion of meat	NA	NA	0.002	NA
	Ingestion of dairy products	NA	NA	0.004	NA
Surface Soil	Ingestion	0.02	NA	NA	NA
	Dermal contact	0.1	NA	NA	NA
	Ingestion of meat	NA	NA	NA	5
	Ingestion of dairy products	NA	NA	NA	2
Surface Water	Ingestion of meat	NA	NA	NA	3
	Ingestion of dairy products	NA	NA	NA	1
Total Hazard Index		0.2	0.5	0.07	11

^aNA - Not applicable. Exposure route not evaluated.

TABLE E.5-3

**SUMMARY OF TOTAL CARCINOGENIC RISKS
CURRENT SOURCE TERM
MAXIMALLY EXPOSED INDIVIDUALS**

Off-Property User of Meat and Milk						On-Property Site Visitor				
Medium	Percent of Total Risk	Radiocarcinogenic Risk/Major Contributors (%)		Chemocarcinogenic Risk/Major Contributors (%)		Percent of Total Risk	Radiocarcinogenic Risk/Major Contributors (%)		Chemocarcinogenic Risk/Major Contributors (%)	
Air	NA	NA		NA		37%	1 x 10 ⁻⁴		3 x 10 ⁻⁶	
							U-238	70	Chromium	80
							Th-230	12	Arsenic	9.7
							U-234	8.5	Cadmium	5.0
Buried Pit Materials	NA ^a	NA		NA		33%	9 x 10 ⁻⁵		NA	
Surface	95%	6 x 10 ⁻⁴		2 x 10 ⁻³		30%	8 x 10 ⁻⁵		NA	
Soil										
		Tc-99	75	Aroclor-1254	94		Th-228	59		
		Sr-90	14	Arsenic	3					
		U-238	5							
Surface	5%	4 x 10 ⁻⁵		7 x 10 ⁻⁶			U-238	16		
Soil										
		U-238	32	Arsenic	100		Ra-226	6.5		
		Cs-137	30							
		Tc-99	27							

^aNA - Not applicable. Exposure route not considered for this receptor.

0670

E-5-24

478

TABLE E.5-4

**SUMMARY OF TOTAL HI
CURRENT SOURCE TERM
MAXIMALLY EXPOSED INDIVIDUALS**

Medium	Off-Property User of Meat and Dairy Products			Off-Property Site Visitor		
	Percent of Total HI	HI/Major Contributors	Percent	Percent of Total HI	HI/Major Contributors	Medium Contribution Percent
Air	11	11 NA	NA	100	0.5	
Surface Soil	64				Cobalt Manganese Barium	87 12 1
Surface Water	36	Silver Zinc Antimony	43 24 14	NA	NA	NA
		Zinc Silver Copper	95 3 1	NA	NA	NA

^aNA = Not applicable

4787

TABLE E.5-5

**TOTAL CARCINOGENIC RISKS AND HAZARD INDICES
FUTURE SOURCE TERM - CURRENT LAND USE
ON-PROPERTY EXPOSURES - TRESPASSING CHILD**

Medium	Exposure Route	Trespassing Child		
		Radiological	Chemical	Hazard Index
Air	Inhalation	2×10^{-4}	1×10^{-4}	0.8
Buried Pit Material	Penetrating Radiation	7×10^{-6}	NA ^a	NA
Surface Soil/Exposed Pit Material	Ingestion	3×10^{-6}	8×10^{-5}	0.9
	Dermal Contact	NA	3×10^{-5}	2
	External Exposure	3×10^{-4}	NA	NA
Sediment - Paddys Run	Ingestion	5×10^{-7}	3×10^{-7}	0.7
	Dermal Contact	NA	2×10^{-5}	0.03
	External Exposure	4×10^{-6}	NA	NA
Subtotal		5×10^{-4}	2×10^{-4}	4
Total Risk/Hazard Index		7×10^{-4}		4

^aNA - Not Applicable - Exposure route not evaluated.

TABLE E.5-6

4787

**TOTAL CARCINOGENIC RISKS AND HAZARD INDICES
FUTURE SOURCE TERM - CURRENT LAND USE
OFF-PROPERTY EXPOSURES - RME RESIDENT**

Medium	Exposure Route	Off-Property RME Resident		
		Radiological	Chemical	Hazard Index
Air	Inhalation	9×10^{-4}	3×10^{-3}	0.4
	Ingestion of Vegetables and Fruit	1×10^{-5}	6×10^{-4}	40
	Ingestion of Meat	3×10^{-7}	2×10^{-4}	6
	Ingestion of Dairy Products	2×10^{-6}	3×10^{-5}	4
Groundwater	Ingestion of Drinking Water	5×10^{-4}	0×10^0	8
	Dermal Contact	NA	0×10^0	0.4
	Inhalation	NA	0×10^0	NA
	Ingestion of Vegetables and Fruit	2×10^{-4}	0×10^0	2
	Ingestion of Meat	1×10^{-6}	0×10^0	0.02
	Ingestion of Dairy Products	1×10^{-5}	0×10^0	0.2
Subtotal		2×10^{-3}	4×10^{-3}	60
Total Risk/Hazard Index		6×10^{-3}		60

^aNA - Not Applicable - Exposure route not evaluated.

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TABLE E.5-7

**TOTAL RADIOCARCINOGENIC RISKS
FUTURE SOURCE TERM - CURRENT LAND USE
OFF-PROPERTY EXPOSURES - GREAT MIAMI RIVER USER**

Medium	Exposure Route	Radiocarcinogenic Risk
Surface Water - Great Miami River	Ingestion of drinking water	2×10^{-7}
	Ingestion of vegetables and fruit	5×10^{-8}
	Ingestion of meat	2×10^{-9}
	Ingestion of milk	1×10^{-8}
	Incidental ingestion while swimming	2×10^{-10}
	Ingestion of fish	1×10^{-8}
Total Risk		3×10^{-7}

TABLE E.5-8

**TOTAL CARCINOGENIC RISKS AND HAZARD INDICES
FUTURE SOURCE TERM - CURRENT LAND USE
OFF-PROPERTY USER OF MEAT AND DAIRY PRODUCTS**

4787

Medium	Exposure Route	Off-Property User of Meat and Dairy Products		
		Radiological	Chemical	Hazard Index
Surface soil/exposed pit material	Ingestion of meat	1×10^{-4}	8×10^{-4}	2
	Ingestion of dairy products	5×10^{-4}	7×10^{-4}	5
On-property surface water	Ingestion of meat	6×10^{-6}	6×10^{-6}	3
	Ingestion of dairy products	3×10^{-5}	8×10^{-7}	1
Subtotal		6×10^{-4}	2×10^{-3}	11
Total Risk/Hazard Index		3×10^{-3}		11

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TABLE E.5-9
TOTAL CARCINOGENIC RISKS
FUTURE LAND USE
ON-PROPERTY EXPOSURES

Medium	Exposure Route	On-Property RME Adult Farmer		On-Property CT Adult Farmer		On-Property RME Child		Home Builder	
		Radiological	Chemical	Radiological	Chemical	Radiological	Chemical	Radiological	Chemical
Air	Inhalation	1×10^{-2}	4×10^{-3}	9×10^{-4}	3×10^{-4}	2×10^{-4}	4×10^{-4}	2×10^{-5}	8×10^{-6}
	Ingestion of Vegetables and Fruit	2×10^{-4}	7×10^{-3}	1×10^{-5}	5×10^{-4}	1×10^{-5}	3×10^{-3}	NA ^a	NA
	Ingestion of Meat	4×10^{-6}	2×10^{-3}	3×10^{-7}	1×10^{-4}	1×10^{-7}	3×10^{-4}	NA	NA
	Ingestion of Dairy Products	3×10^{-5}	4×10^{-4}	2×10^{-6}	2×10^{-5}	8×10^{-6}	4×10^{-4}	NA	NA
Buried Pit Material	Penetrating Radiation	1×10^{-3}	NA	2×10^{-4}	NA	2×10^{-7}	NA	3×10^{-6}	NA
	Indoor Radon	1×10^{-7}	NA	NA	NA	NA	NA	NA	NA
Surface Soil/Exposed Pit Material	Ingestion	4×10^{-4}	1×10^{-2}	4×10^{-5}	8×10^{-4}	4×10^{-5}	6×10^{-3}	3×10^{-7}	3×10^{-5}
	Dermal Contact	NA	2×10^{-3}	NA	2×10^{-4}	NA	3×10^{-4}	NA	5×10^{-4}
	External Exposure	2×10^{-2}	NA	4×10^{-3}	NA	3×10^{-3}	NA	2×10^{-6}	NA
	Ingestion of Vegetables and Fruit	9×10^{-5}	2×10^{-4}	5×10^{-6}	4×10^{-5}	6×10^{-6}	6×10^{-5}	NA	NA
	Ingestion of Meat	1×10^{-4}	8×10^{-4}	6×10^{-6}	6×10^{-5}	3×10^{-6}	1×10^{-4}	NA	NA
	Ingestion of Dairy Products	5×10^{-4}	7×10^{-4}	4×10^{-5}	5×10^{-5}	1×10^{-4}	8×10^{-4}	NA	NA

TABLE E.5-9
(Continued)

Medium	Exposure Route	On-Property RME Adult Farmer		On-Property CT Adult Farmer		On-Property RME Child		Home Builder	
		Radiological	Chemical	Radiological	Chemical	Radiological	Chemical	Radiological	Chemical
Groundwater	Ingestion of Drinking Water	7×10^{-3}	3×10^{-2}	5×10^{-4}	2×10^{-3}	4×10^{-4}	8×10^{-3}	NA	NA
	Dermal Contact While Bathing	NA	8×10^{-5}	NA	5×10^{-6}	NA	1×10^{-5}	NA	NA
	Ingestion of Vegetables and Fruit	2×10^{-3}	1×10^{-2}	1×10^{-4}	7×10^{-4}	2×10^{-4}	4×10^{-3}	NA	NA
	Ingestion of Meat	2×10^{-5}	2×10^{-3}	1×10^{-6}	1×10^{-4}	5×10^{-7}	3×10^{-4}	NA	NA
	Ingestion of Dairy Products	2×10^{-4}	2×10^{-4}	1×10^{-5}	1×10^{-5}	5×10^{-5}	2×10^{-4}	NA	NA
On-Property Surface Water	Ingestion of Meat	5×10^{-6}	6×10^{-6}	4×10^{-7}	4×10^{-7}	2×10^{-7}	1×10^{-6}	NA	NA
	Ingestion of Dairy Products	3×10^{-5}	8×10^{-7}	2×10^{-6}	5×10^{-8}	8×10^{-6}	9×10^{-7}	NA	NA
Perched Water	Ingestion of Drinking Water ^b	7×10^{-1} (5×10^{-1}) ^c	1×10^{-1} (1×10^{-1}) ^c	5×10^{-2} (5×10^{-2}) ^c	1×10^{-2}	4×10^{-2} (4×10^{-2}) ^c	4×10^{-2} (4×10^{-2}) ^c	NA	NA
Subtotal		4×10^{-2} (3×10^{-2}) ^c	7×10^{-2} (5×10^{-2}) ^c	6×10^{-3}	4×10^{-3}	4×10^{-3}	2×10^{-2} (2×10^{-2}) ^c	3×10^{-5}	5×10^{-4}
Total Carcinogenic Risk		1×10^{-1} (8×10^{-2}) ^c		1×10^{-2} (1×10^{-2}) ^c		2×10^{-2} (2×10^{-2}) ^c		6×10^{-4}	

^aNA - Not applicable - exposure route not evaluated.

^bRisks not included in totals.

^cCalculated using the one-hit model.

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TABLE E.5-10

**TOTAL HAZARD INDICES
FUTURE LAND USE
ON-PROPERTY EXPOSURES**

Medium	Exposure Route	On-Property RME Adult	On-Property CT Adult	On-Property RME Child	Home Builder
Air	Inhalation	5	3	5	0.3
	Ingestion of Vegetables and Fruit	280	150	1200	NA
	Ingestion of Meat	8	4	13	NA
	Ingestion of Dairy Products	38	20	510	NA
Surface Soil/Exposed Pit Material	Ingestion	27	12	140	30
	Dermal Contact	7	2	11	60
	Ingestion of Vegetables and Fruit	16	2	11	NA
	Ingestion of Meat	3	1	5	NA
	Ingestion of Dairy Products	5	3	66	NA
Groundwater	Ingestion of Drinking Water	200	100	630	NA
	Dermal Contact While Bathing	6	3	14	NA
	Ingestion of Vegetables and Fruit	60	30	210	NA
	Ingestion of Meat	4	2	34	NA
	Ingestion of Dairy Products	4	2	55	NA
Surface Water - On-Property	Ingestion of Meat	3	2	5	NA
	Ingestion of Dairy Products	1	0.7	150	NA
Perched Water	Ingestion of Drinking Water ^b	6000	3100	17,000	NA
Total Hazard Index		670	340	3100	90

^aNA - Not applicable - Exposure route not evaluated.

^bNot included in total hazard indices.

TABLE E.5-11

**SUMMARY OF TOTAL CARCINOGENIC RISKS
FUTURE SOURCE TERM
MAXIMALLY EXPOSED INDIVIDUALS**

On-Property RME Resident Adult Farmer				Off-Property RME Resident Adult Farmer			
Medium	% Total Risk	Radiocarcinogenic Risk/Major Contributors (%)	Chemocarcinogenic Risk/Major Contributors (%)	% Total Risk	Radiocarcinogenic Risk/Major Contributors (%)	Chemocarcinogenic Risk/Major Contributors (%)	
Air	20%	1 x 10 ⁻²	1 x 10 ⁻²	88%	9 x 10 ⁻⁴	4 x 10 ⁻³	
		Th-230 56	Arsenic 100		Th 230 59	Nickel 65	
		U-238 19			U-238 23	Arsenic 35	
		U-234 7.2			U-234 8.1		
Buried Pit Material	<1%	1 x 10 ⁻³	NA ^a	NA	NA	NA	
Surface Soil/	30%	2 x 10 ⁻²	1 x 10 ⁻²	NA	NA	NA	
Exposed Pit Contents		Th-232 60	Arsenic 69				
		Ra-226 32	Aroclor-1254 8.5				
		U-238 2.7	Beryllium 7.7				
Groundwater	49%	9 x 10 ⁻³	4 x 10 ⁻²	12%	7 x 10 ⁻⁴	0	
		U-238 88	Arsenic 100		U-238 86	NA	
		U-234 10			U-234 10		
		U-235 2			U-235 2.4		
Surface Water	<1%	4 x 10 ⁻⁵	7 x 10 ⁻⁶	NA	NA	NA	
		U-238 39	Arsenic 100		NA	NA	
		Tc-99 28					
		Cs-137 21					

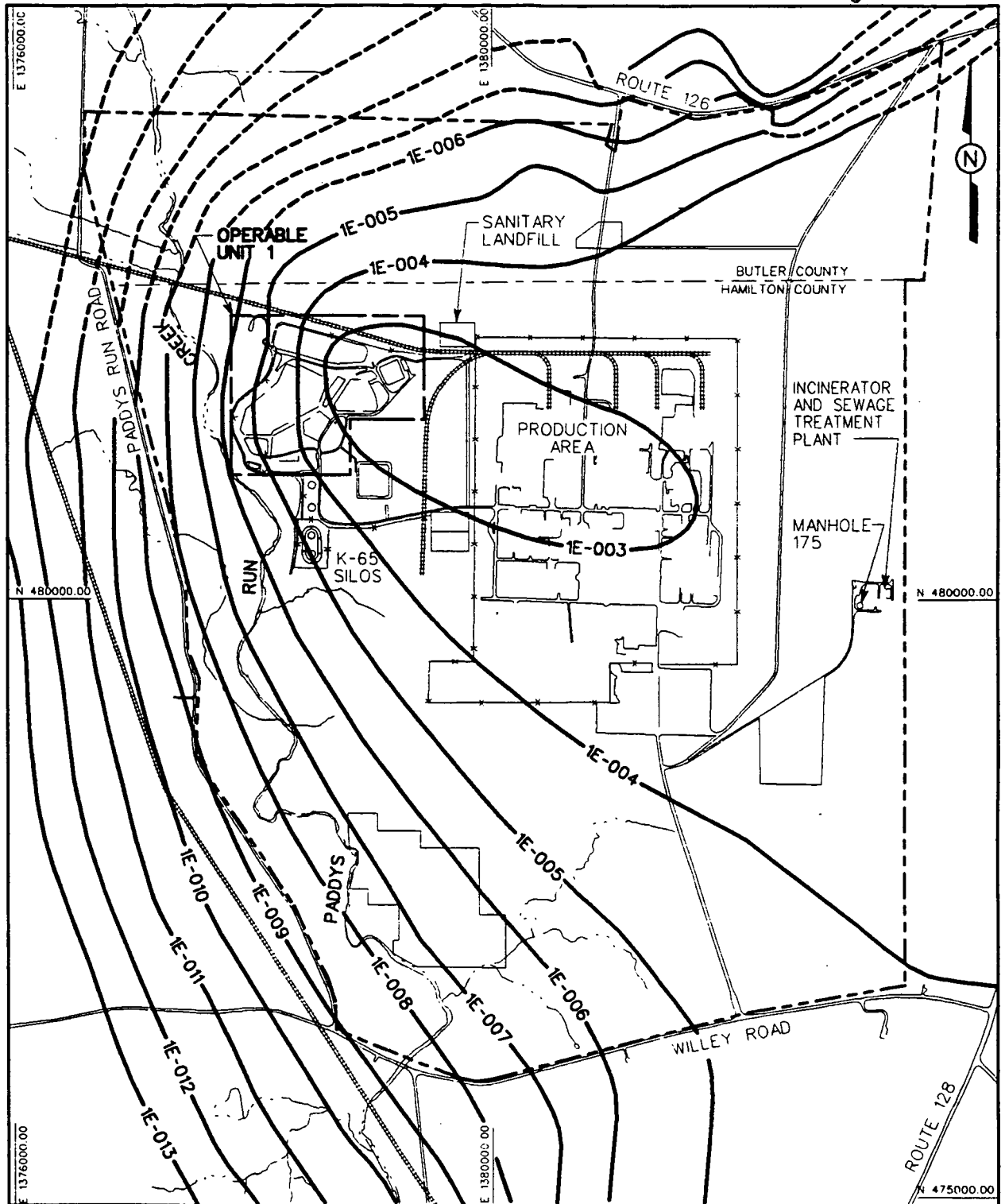
^aNA - Not applicable.

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TABLE E.5-12
SUMMARY OF TOTAL HI
FUTURE SOURCE TERM
MAXIMALLY EXPOSED INDIVIDUALS

Medium	On-Property RME Resident Child			On-Property RME Resident Adult Farmer		
	Percent of Total HI	HI/Major Contributors	Percent	Percent of Total HI	HI/Major Contributors	Percent
Air	56	1700		49	330	
		Uranium	94		Uranium	94
		Arsenic	4		Arsenic	5
		Zinc	1			
Surface Soil/Exposed Pit Material	8	230		9	60	
		Arsenic	56		Arsenic	43
		Silver	18		Antimony	27
		Antimony	5		Uranium	11
Groundwater	30	940		41	270	
		Uranium	60		Uranium	59
		Arsenic	27		Arsenic	29
		Antimony	8		Antimony	8
Surface Water	5	160		1	4	
		Silver	87		Zinc	93
		Zinc	14		Silver	5

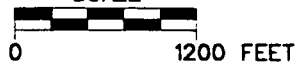
*NA = Not applicable



NOTES:

1. MAX. ON-PROPERTY RISK-
 6.0×10^{-2} (830 YRS.)
2. MAX. OFF-PROPERTY RISK-
 6.2×10^{-2} (880 YRS.)
3. CONTOURS ARE DASHED WHERE
INFERRED.

SCALE:



LEGEND:

- x—x— FENCE LINE
- DRAINAGE WAY
- ==== CSX RAIL LINE
- == ROADWAY
- OPERABLE UNIT 1 OUTLINE
- FEMP PROPERTY BOUNDARY
- IE-010- CONCENTRATION CONTOUR

408191-A-349 / QUT / 10/01 / DS
408191-A-349 / QUT / 08/13/93 GP

FIGURE E.5-1. TOTAL CARCINOGENIC RISK ASSOCIATED WITH GROUNDWATER USE

E.6.0 UNCERTAINTIES

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The types and magnitudes of uncertainties associated with each stage of the process are of major importance for evaluating and interpreting risk assessments at the FEMP. Uncertainties associated with calculations that occur in the risk assessment may be magnified in the final results. While it is not possible to eliminate all uncertainty from the analysis, it must be identified and discussed to determine their significance when making risk management decisions. This section presents an analysis of the major uncertainties contributing to the final results of the Operable Unit 1 baseline risk assessment.

E.6.1 TERMINOLOGY

This section introduces the evaluation of uncertainties inherent in the risk assessment process. Uncertainty is a measure of inaccuracy that must be considered in each step of the CPC selection process, exposure and toxicity assessments and risk characterization presented in the preceding sections. Each portion of the analysis contributes to the uncertainty of the final risk assessment. Uncertainty in CPC selection is primarily associated with the analytical data and procedures used to include or exclude constituents as CPCs. Uncertainty associated with the exposure assessment includes variations in sample analytical results, the values used for variables as input to a given intake route, the methods used and assumptions made to determine exposure point concentrations, the accuracy with which a particular fate and transport model represents actual environmental processes, and the manner in which the exposure scenario is developed. Uncertainty associated with the toxicity assessment includes the quality of the existing data to support a dose-response assessment, the high-to-low dose and interspecies extrapolations for dose-response relationships, and the weight of evidence used for determining the carcinogenicity of CPCs. Uncertainty associated with risk characterization includes that associated with exposure to multiple chemicals (i.e., additivity of dose, synergisms and antagonisms among chemicals, and the particular mode of action for each chemical), and the cumulative uncertainty from combining conservative assumptions made in the data, exposure assessment, and toxicity assessment. Each of these categories of potential uncertainty is discussed in this section.

Generally, risk assessments carry two types of uncertainty, measurement and informational uncertainty; each merits consideration. Measurement uncertainty refers to the usual variance that accompanies scientific measurements (e.g., instrument uncertainty associated with contaminant concentrations). This type of uncertainty is generally associated with the analytical data, which impacts CPC selection and calculation of exposure point concentrations. The risk assessment results reflect the accumulated variances of the individual measured values used. A different kind of uncertainty stems from inadequate availability of information needed to complete the toxicity and exposure assessments.

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Often this informational gap is significant, such as the absence of information on the effects of human exposure to low doses of a chemical or on the biological mechanism of action of an agent (EPA 1992d).

Once the risk assessment is complete, the results must be reviewed and evaluated to identify the type and magnitude of uncertainty involved. Reliance on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the risk assessment process can often be misleading. For example, to account for uncertainties in the development of exposure assumptions, conservative estimates must be made to ensure that the particular assumptions made are protective of all sensitive subpopulations, or maximum exposed individuals. If a number of conservative assumptions are combined in an exposure model, the resulting calculations can propagate the uncertainties associated with those assumptions, producing a much larger uncertainty for the final results. Thus, both the risk assessment's results and the uncertainties associated with those results should be considered when making risk management decisions.

This interpretation is especially relevant when resulting risk numbers exceed the point-of-departure for defining acceptable risk. For example, when risks are calculated that incorporate a high degree of uncertainty fall below an acceptable risk level (e.g., below an incremental lifetime cancer risk [ILCR] of 10^{-6}), the interpretation is easy and very straight forward. However, when calculated risks incorporate a high degree of uncertainty fall above an acceptable risk level (e.g., below an ILCR of 10^{-4}), a conclusion can be difficult to make unless it considers all of the uncertainties inherent in the calculations.

The actual risk may be one, two, or even three orders of magnitude smaller than the one calculated, which could lead risk managers to make a decision which is unnecessarily protective. This situation may occur in a Superfund risk assessment when the estimated risk were based on limited information for the calculational parameters, conservative assumptions on lifestyles and land-use scenarios, and maximum or near-maximum values for many of the modeling and exposure variables to ensure that the risks are not underestimated. The combination of conservative assumptions over a number of areas often results in high risk values as a result of high uncertainty. Characterization of risk based on overly conservative model parameters, scenarios, and assumptions does not convey realistic information and is often misleading if reviewed out of context. A risk estimate for an RME individual in a Superfund risk assessment has been frequently mistakenly viewed as an average risk to the receptor population being evaluated (EPA 1992d).

Such conservatism has been incorporated into the RME scenarios for Operable Unit 1 risk assessment. Although it is possible that the exposure, dose, and sensitivity combinations assumed might occur in the receptor population of interest, the probability of an individual actually receiving this degree of exposure is expected to be low.

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Recent EPA guidance on risk assessment (EPA 1992d) requires risk assessors to use exposure and toxicity assumptions that are from the "high end" and "central tendency" of their distributions. These values correspond to the reasonable maximum exposure (RME) and central tendency (CT) scenarios, respectively, for the risk assessment. The RME scenario is to be a combination of average and upper-bound assumptions that estimate the reasonable maximum exposure for that pathway. The resulting risk for the RME scenario is assumed to fall between the average (i.e., the CT scenario) and the upper-bound scenario (a scenario that is based on all maximum values). The CT scenario is a combination of all average and median values for exposure parameters that provide an estimate of average risk posed to the receptor population being considered. It should be noted here that the CT scenario used in Operable Unit 1 uses many maximal values at the request of EPA Region V. The purpose for consideration of risks from both the CT and RME scenarios is to provide bounds on the expected risks posed by the site.

The ultimate goal of the risk assessment process is to provide an objective, realistic, and balanced risk estimate for making a risk management decisions at the FEMP. In the past, Superfund risk assessments based on the "Risk Assessment Guidance for Superfund" (EPA 1989a) yielded calculated risks only for RME scenarios. In an attempt to incorporate this concept into the risk assessments of FEMP, the risk assessment for Operable Unit 1 includes an additional scenario considering some average assumptions for the on-property resident adult. Based on the future land-use scenario, the on-property resident adult constitutes the most important receptor since they have the highest risk. This attempt at characterizing the CT scenario side-by-side with the RME scenario serves to present a more realistic estimate of the range of possible risk for this receptor. Efforts will continue to incorporate the guidance as more exposure data at the FEMP become available and the additional guidance on estimating CT is completed by EPA.

E.6.2 SOURCES OF UNCERTAINTY IN OPERABLE UNIT 1

As noted previously, uncertainties are associated with the information and data used for the selection of CPCs, exposure and toxicity assessments, and risk characterization for the Operable Unit 1 baseline risk assessment. Uncertainty in the selection of CPCs is associated with the analytical data. In the exposure assessment, these uncertainties are the result of a number of factors, including assumptions on land use and receptors, assumptions made for parameters and parameter variability (random errors or natural variations), and the necessity of using computer models to predict complex environmental interactions. Uncertainty associated with the toxicity assessment is associated with the dose-response data. As EPA has pointed out in their guidance for human health risk assessments, "it is more important to identify the key site-related variables and assumptions that contribute most to the uncertainty than to precisely quantify the degree of uncertainty in the risk assessment" (EPA 1989a). Uncertainties are evaluated in this section to provide a basis for interpreting the overall quality of the risk assessment results. Sources of uncertainty are discussed below.

E.6.2.1 Selection of Constituents of Potential Concern

Uncertainty associated with the selection process used to determine the CPCs in Operable Unit 1 can be attributed to the following sources:

- Soil and groundwater data do not exist for the area directly beneath the waste pits and were inferred from indirect data sources. Data taken from adjacent borings and wells were used to estimate these conditions. These data were also used to determine which constituents are migrating toward the aquifer, and at what rate this migration is occurring.
- Sample results from the RI/FS and CIS sampling programs could not be combined, and, therefore, were evaluated separately in the data evaluation process. Each sampling and analysis program identified chemicals that were not identified by the other. This introduces uncertainties in the presence or absence of some of the chemicals reported and limits that data that is used to statistically determine source concentrations.
- CIS samples taken from the split-spoon sampler were immediately dissected into discrete depth samples for radiological analysis. Composites of the remaining soil were made in the open air and placed into sampling containers. As a result, concentrations of volatile chemicals may be underestimated since they may have volatilized during this sampling procedure.
- Evaluation of the existing data raises the question as to whether all pockets of elevated contamination have been identified. In general, it is believed that they have been identified for most radionuclides at the FEMP because CIS sampling locations were generally biased, based on high radiation measurements in the field. This is particularly important because risks from radionuclides dominate the overall risks to all receptors evaluated in this risk assessment. No conclusion can be drawn for chemical constituents detected on the property.
- Sample analytical techniques produce results that have an unknown degree of uncertainty associated with them. These uncertainties are documented by using data qualifiers to reflect the assumed degree of certainty of measurement. These analytical uncertainties affect the selection of CPCs or the calculation of exposure point concentrations (either measured or modeled) that may be based on a particular analytical result.
- Concentrations of inorganics and radionuclides are compared to background concentrations to determine if their presence is due to naturally occurring concentrations from native soils or are due to site activities. However, sampling procedures for groundwater and air used to determine background concentrations have high detection limits. A chemical that was not detected during background sampling could result in the erroneous inclusion of a chemical from those selected for further evaluation.
- The RI organics data for the waste pit material were rejected during validation because of holding time problems and sampling techniques. However, several compounds were noted, and the exclusion of these compounds as CPCs may underestimate risks.
- A limited number of samples exists for some media for a number of waste pits. A limited database has a potential to introduce either false positives (i.e., introducing

constituents as CPCs that are not site related) or false negatives (i.e., screening out constituents that are site related and could contribute to site risks) into the selection of CPCs.

4787

The cumulative impacts of these uncertainties on the results of the exposure and risk assessments are judged to be low to moderate (i.e., are assumed to result in over or underestimation of risk by an order of magnitude or more). This is because a few constituents contribute the majority of the cancer risk for most receptors. Two examples are external radiation exposure from U-238 and its immediate progeny, and arsenic in water. Risks from these constituents each exceed 10^{-4} by themselves. The relative contributions of these two constituents to the total risk are so significant that a change in the total risk would be slight if other chemicals were added or deleted from the list of CPCs selected for evaluation in this risk assessment.

E.6.2.2 Uncertainty in Exposure Assessment

Sources of uncertainty for the exposure assessment arise from selection of calculation of exposure point concentrations, selection of receptors, determination of land use scenarios and selection of exposure factors.

E.6.2.2.1 Exposure Point Concentrations

Uncertainty associated with calculation of exposure point concentrations in Operable Unit 1 can be attributed to the following sources:

- The material in the waste pits has been determined to be very heterogeneous in nature. In the effort to obtain radiological samples at the most contaminated locations, a radiological survey of the study area was conducted. Waste pit borings were placed at the locations having the highest gross radiation measurements. Selection of sampling locations in this way leads to a positive bias in the calculation of exposure point concentrations for certain radionuclides and uncertainty in the representativeness of the samples.
- According to the "Risk Assessment Guidance for Superfund" (EPA 1989a), the UCLs are used for all exposure concentrations. This means that 95 percent of the time, the actual mean concentration can be less than the value used in the exposure assessment. Conversely, 5 percent of the time the actual mean concentration can be greater than the value used in the exposure assessment. Therefore the exposure assessment may underestimate the exposures in 5 percent of the cases, and overestimate exposures 95 percent of the time.
- A limited number of samples for some waste pits introduces high uncertainty in the determination of exposure point concentrations for some compounds.
- Sample analytical techniques produce results that have a degree of uncertainty associated with them. These uncertainties are documented by using data qualifiers to reflect the degree of uncertainty of measurement. These analytical uncertainties affect the exposure

point concentrations (either measured or modeled) that may be based on a particular analytical result.

- There is also large uncertainty when exposure concentrations were based on the maximum detected concentration. The conservative approach was taken in the statistical interpretation of the RI and CIS data bases (i.e., if less than four detections, the maximum concentration is used as the representative), and may result in an overestimation of the concentrations to which a receptor could be exposed.

Predicted concentrations were used as exposure point concentrations when measured data were not available (e.g., the future). These predictions were made using mathematical representations (models) of the natural systems found or suspected to exist in the study area. Due to the complexity of natural environments, conservative assumptions were often used in these models to calculate exposure point concentrations. When a number of conservative assumptions are combined into one fate and transport model, the uncertainties are compounded and provide very conservative estimates of the exposure point concentration. These assumptions are typically made to avoid underestimating the concentrations of contaminants in transport or exposure media (e.g., air or groundwater). As a result, transport parameters are chosen from the upper bound of possible alternative values. Thus the uncertainties associated with modeled concentrations are generally much larger than those associated with measured data. Uncertainties associated with modeled exposure point concentrations in Operable Unit 1 can be attributed to the following sources:

- The geochemical model has several sources of uncertainty associated with it. The conceptual model assumes that mineral phases represent the actual solid phases of a chemical in the waste material. In addition, the geochemical model assumes dissolution and precipitation kinetics are instantaneous, and it does not evaluate adsorption processes. This leads to estimates of concentrations that are too high or too low.
- A limited number of organic chemicals can be accommodated by the geochemical model used to determine Leachate B concentrations in the till. This leads to low estimates of leachate concentrations for some inorganic constituents if complexation occurs with organic chemicals not present in the database.
- Total contact between the waste and the leaching fluid and no containment of the leachate concentrations are assumed. This produces higher estimated concentrations of Leachate B available for transport to the aquifer than would be anticipated under actual conditions. This uncertainty is reduced by the availability of in situ leachate concentrations for most chemicals in most sources.
- Use of Toxicity Characteristic Leaching Procedure (TCLP) data to characterize leachate concentrations in the natural environment adds conservatism to the groundwater fate and transport modeling process because TCLP leaching is performed with an acidic solution. This tends to overestimate the leachate concentration of inorganics over natural (more neutral) leaching conditions.
- The selection of parameters related to the attenuation and retardation of constituents is a major uncertainty in the analysis. The attenuation and retardation factors of every

constituent except uranium were determined after an extensive literature search. It should be noted here that the actual retardation factors at the FEMP may not follow the assumed literature values, particularly over the long term. Site-specific attenuation and retardation factors are used when available. The use of site-specific values are assumed to result in lower uncertainty than using literature values.

- The organic decay rates at the FEMP were determined after an extensive literature search. The actual decay rates may or may not follow the assumed literature values because of site-specific conditions. The use of site data to determine organic decay rates is assumed to result in lower uncertainty than that resulting from the use of literature values.
- Transport through the vadose zone is approximated by using a one-dimensional model and assuming the zone is homogeneous. The unsaturated seepage flow rate is a function of several parameters, such as porosity, residual saturation, and pore size distribution index. Due to the heterogeneous nature of the till, these parameters change from location to location and from depth to depth.
- The total mass of each contaminant is calculated by multiplying the UCL by the volume of the entire waste area, thus assuming the UCL concentration is uniformly distributed through the entire source.
- The fate and transport modeling used a "70-year rule" for these constituents where no or inadequate leachate data exist. This "rule" assumes all the chemical leaches from a particular waste unit in 70 years. This method is considered very conservative for compounds that are insoluble but may underestimate the maximum exposure for soluble compounds. The application of this procedure in a risk assessment primarily effects systemic toxicants, four of which were evaluated in the Operable Unit 1 baseline risk assessment (benzo[g,h,i] fluoranthene, benzo[g,h,i]perylene, fluoranthene, and phenanthrene). However, the application of this methodology to these constituents is considered conservative because these particular compounds have rather low solubilities and high partitioning coefficients. PAHs, in general, contribute an insignificant proportion to the total hazard index. Therefore, the application of this assumption is assumed to have a low impact on the risk assessment.
- Air modeling is based on a number of conservative assumptions. In combination these assumptions appear to overestimate the exposure point concentrations for air based on site air monitoring data and according to a literature search for typical ambient air PM₁₀ measurements for EPA Region V. The long-term average PM₁₀ concentrations calculated are comparable to measured dust concentrations on constructions. This uncertainty is expected to moderately overestimate risk (i.e., overestimate risks by 1 to 2 orders-of-magnitude).
- Contaminant concentrations for the surface soil over Waste Pits 1-4 is not available. Air modeling is performed assuming that soil concentrations over the pits is equal to contaminant levels of surface soil between the pits. The impact of this assumption is assumed to be low.
- The future configuration of the waste pits is uncertain at this time; thus, a reasonable worst-case configuration is used to determine source concentrations for both air and surface water modeling. If the actual configuration differs from that used in this

evaluation, the future source concentrations may change and the models will have incorrectly estimated the exposure point concentrations.

- The transport models individually made assumptions regarding the fate of individual constituents within source media. However, these models were not combined or linked to consider assumptions made regarding depletion of chemicals from one model and the effect of that assumption on another model (i.e., the leaching models did not consider source depletion from volatilization or fugitive emissions and the air emissions models did not consider losses via leaching). Furthermore, the direct exposure pathways to a particular source (i.e., incidental ingestion of surface soil) did not consider source depletion by leaching, surface water transport, or air emissions. Consequently, this assumption is considered very conservative.

These uncertainties for modeling collectively are assumed to moderately overestimate the concentrations expected in groundwater and for aerial deposition (i.e., overestimate concentration and risk by a factor of one to two orders of magnitude).

Models were also used to calculate chemical concentrations in plants and animals. Each time concentrations at one level in the food chain are extrapolated from a lower level, uncertainty is introduced into the result. For example, soil-to-plant transfer factors (B_{1v} values) generally represent the maximum amount of contaminant transfer that may occur. In reality, the contaminant transfer is quite dependent on the form of the constituent (e.g., metal species) and other site-related physical conditions (e.g., soil type). Thus actual site transfer factors are unknown. The values chosen are intended to be conservative and they are likely to overestimate risk.

E.6.2.2.2 Determination of Land Uses

A major uncertainty associated with predicting future exposures at the FEMP is the future disposition of the property itself. Because it is not possible to accurately predict what the future uses of the land may be the most conservative (rather than the most likely) land use is evaluated, as stipulated by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). As noted in Section E.3.0, one of the on-property residents evaluated under future land use for Operable Unit 1 is the resident farmer. It is unlikely that the waste pits and surrounding soils could support a viable agricultural receptor, but the assumption of the resident farmer for future land use provides a worst-case scenario regarding future land use in the exposure assessment.

E.6.2.2.3 Selection of Receptors

The receptors selected for evaluation in this assessment have been generally selected to reflect and encompass those types of activities which may produce the reasonable maximum exposure individual. Some of these receptors, such as the on-property resident farmer living on the open waste pit, can possibly exist in the future but this scenario is considered very unlikely based on the use of this area for waste disposition. Risks from such a receptor may overstate probable risk from future use of the property when considered against more plausible land use alternatives. Uncertainty associated with the

selection of receptors in the current land use scenario is assumed to be low (over- or underestimate risks by a one order of magnitude or less) because the current site environmental setting and configuration was the basis for selection of these receptors. Uncertainty associated with receptors identified in the future land use scenario is high (i.e., potential to overestimate risk by two or more orders-of-magnitude) due to the low probability of the site being used as a residence or for agricultural purposes.

E.6.2.2.4 Determination of Exposure Factors

Each exposure factor selected for use in this risk assessment has some uncertainty associated with it. Generally these factors are based on surveys of physiological and lifestyle profiles across the United States. The attributes and activities studied in these surveys generally have a broad distribution. To avoid the underestimation of exposure, this risk assessment followed EPA's recommendation and used the 95th percentile for most of the exposure parameters used in this risk assessment. In other words, the values selected represent the observed or expected habits of a small percentage of the population (usually the upper 5 or 10 percent). For example, the resident farmer scenarios were assumed to inhale air at the location of the highest annual average concentration for 350 days per year for 70 years. Seventy years represents the maximum exposure duration and is not based on a statistical assessment of local or regional residence time for farm families.

Generally, the uncertainty can be assessed quantitatively for a number of assumptions made in determining factors for calculating exposure and intakes. Many of these parameters were determined from statistical analyses on human population characteristics. Often the database used to summarize a particular exposure parameter (i.e., inhalation rate) is quite large. Consequently, the values chosen for such variables in the RME scenario have low uncertainty (i.e., over or underestimate risks by one order of magnitude or less). For many parameters for which limited information exists (i.e., dermal adsorption of organic chemicals from soils), there is greater uncertainty. However, there is often sufficient data to estimate these parameters with low uncertainty. Few intake parameters have high uncertainty associated with them. In the risk assessment for Operable Unit 1, the particular exposure parameters with the greatest uncertainty are judged to be those associated with time (combination of frequency and duration on the site). The particular exposure pathways with the combination of exposure parameters with the highest uncertainty is dermal contact, which is assumed to result in moderate uncertainty (over- or underestimate actual exposure by one to two orders of magnitude) for exposure.

Many of the quantities used to calculate exposures and risks in this report are selected from a distribution of possible values. For the RME scenarios, the value representing the 95th percentile is generally selected for each parameter to assure that the assessment bounds the actual risks from a postulated exposure. This risk number is used in risk management decisions, but does not indicate what a more average exposure might be, or what risk range might be expected for individuals in the

4787

exposed population. To address these issues, a risk estimate closer to the central tendency is presented for the maximally exposed individual using the CT scenario described in Section E.3. The range of risk for this receptor from the CT scenario to the RME scenario seeks to incorporate the range of uncertainty regarding intake assumptions for this receptor.

E.6.2.3 Toxicity Assessment

Uncertainty associated with the toxicity assessment is associated with hazard assessment and dose-response evaluations for CPCs. The hazard assessment deals with characterizing the nature and strength of the evidence of causation, or the likelihood that a chemical that induces adverse effects in animals will induce adverse effects in humans. Hazard assessment of carcinogenicity is evaluated as a weight-of-evidence determination, using either the IARC (1987) or EPA (1986b) methods. Positive animal cancer test data suggest that humans contain tissue(s) that may also manifest a carcinogenic response; however, the animal data cannot necessarily be used to predict the target tissue in humans. In the hazard assessment of noncancer effects, however, positive animal data suggest the nature of the effects (i.e., the target tissues and type of effects) anticipated in humans (EPA 1989i).

Uncertainty in hazard assessment arises from the nature and quality (sensitivity and selectivity) of the animal and human data. Uncertainty is decreased when similar effects are observed across species, strain, sex, and exposure route; when the magnitude of the response is clearly dose-related; when pharmacokinetic data indicate a similar fate in animals and humans; when postulated mechanisms of toxicity are similar for humans and animals; and when the CPC is structurally similar to other chemicals for which the toxicity is more completely characterized. A unique source of uncertainty in cancer hazard assessment involves the relevance of liver tumors in strains of mice with a high background incidence, especially when these tumors provide the only positive response (Scala 1991). Many chlorinated organic chemicals in EPA cancer weight-of-evidence Group B2 fall into this category.

Uncertainty in the dose-response evaluation includes the determination of a slope factor for the carcinogenic assessment and derivation of an RfD or RfC for the noncarcinogenic assessment. Uncertainty is introduced from interspecies (animal-to-human) extrapolation, which, in the absence of quantitative pharmacokinetic, dosimetric, or mechanistic data, is usually based on consideration of interspecies differences in basal metabolic rate. Uncertainty also results from intraspecies, or individual, variation. Most toxicity experiments are performed with animals that are very similar in age and genotype, so that intragroup biological variation is minimal, but the human population of concern may reflect a great deal of heterogeneity including unusual sensitivity or tolerance to the CPC. Even toxicity data from human occupational exposure reflect a bias because only those individuals sufficiently healthy to attend work regularly and those not unusually sensitive to the CPC, are likely to be occupationally exposed. Finally, uncertainty arises from the quality of the key study (from which the quantitative estimate is derived) and the database. For cancer effects, the uncertainty associated

with dose-response factors is mitigated by assuming the 95 percent upper bound for the slope factor. Another source of uncertainty regarding quantitative risk estimation for the carcinogenic assessment is the method by which data from high doses in animal studies are extrapolated to the dose range expected for environmentally exposed humans. The linearized multistage model, which is used in nearly all quantitative estimations of human risk from animal data, is based on a nonthreshold assumption of carcinogenesis. An impressive body of evidence, however, suggests that epigenetic carcinogens, as well as many genotoxic carcinogens, have a threshold below which they are noncarcinogenic (Williams and Weisburger 1991); therefore, the use of the linearized multistage model is conservative for chemicals that exhibit a threshold for carcinogenicity.

For noncancer effects, additional uncertainty factors may be applied in the derivation of the RfD or RfC to mitigate poor quality of the key study or gaps in the database. Additional uncertainty for noncancer effects arises from use of an effect level in the estimation of an RfD or RfC, because this estimation is predicated on the assumption of a threshold below which adverse effects are not expected. Therefore, an additional uncertainty factor is usually applied to estimate a no-effect level. Additional uncertainty arises from estimation of an RfD or RfC for chronic exposure from less than chronic data. Unless empirical data indicate that effects do not worsen with increasing duration of exposure, an additional uncertainty factor is applied to the no-effect level in the less than chronic study. Uncertainty in the derivation of reference doses is mitigated by the use of uncertainty and modifying factors that normally range between three and ten. Uncertainty factors (UF) and modifying factors (MF) are assigned as follows:

- A UF of ten is used to account for sensitive subpopulations.
- A UF of ten is used when extrapolating from animals to humans to account for interspecific variability.
- A UF of ten is applied to a NOAEL (no observed adverse effect level) derived from a subchronic study rather than a chronic study.
- A UF of ten is applied to a LOAEL (lowest observed adverse effect level) to estimate a NOAEL.
- An MF from >0 to ten is applied to data to reflect the quality of the data from the critical study used to derive the reference dose.

As a result, a combination of uncertainty and modifying factors may exceed 100, 1000, or more for a particular compound. These uncertainty factors are discussed in Section E.4 for the CPCs in Operable Unit 1.

Uncertainty arises in the dose-response assessment for Operable Unit 1 for values derived for principle CPCs from studies with limitations. As an example of this type of uncertainty, consider the toxicity

information for uranium. Uranium as an alpha particle emitter is also considered a carcinogen; however, epidemiological evidence of uranium-induced excess cancer risks are very difficult to obtain. This is largely because the human data available for radiocarcinogenic effects of uranium exposure are for underground miners, who are also simultaneously exposed to radon and radon progeny as a confounding factor. The studies of humans sometimes lack information concerning uranium exposure, potential uranium exposure through previous employment, concurrent smoking patterns, or concurrent radon exposure levels that are needed to more definitively determine the risk attributable to uranium exposure. The human studies of cancer from exposure to uranium frequently reveal a slight excess risk above the natural risk. These facts weaken the power of the human studies to detect any excess risk. These uncertainties are not well known or easily determined and, as a consequence, introduce moderate to high uncertainty into the Operable Unit 1 risk assessment.

Other toxicity information used in the Operable Unit 1 risk assessment that introduces uncertainty include:

- The EPA inhalation slope factor of 7.7×10^{-12} pCi⁻¹ for Rn-222 plus its daughters is used to calculate risks resulting from indoor inhalation of radon gases. The EPA bases this slope factor on a 50% equilibrium ratio between Rn-222 and its short-lived daughters. Studies cited in NCRP Report No. 78 (NCRP, 1984) report a lower value for this equilibrium ratio in indoor air (i.e.: 100/50/30/20/20 for Ra-222, Po-218, Pb-214, Bi-214, and Po-214, respectively). Since the concentration of daughters expected in indoor air is lower than the EPA assumption, the slope factor is probably conservative in this respect.
- PAHs that are classified as B2 probable human carcinogens for which no toxicity data were available are evaluated using benzo(a)pyrene toxicity data. This assumption likely leads to an overestimation of the carcinogenicity of those PAHs because conservative assumptions were used to relate their carcinogenicity to that of benzo(a)pyrene. However, when toxicity equivalency factors were used in this assessment to evaluate their carcinogenicity, this may either underestimate or overestimate the carcinogenic risks. Overall, this increased conservatism does not significantly impact the overall risks from Operable Unit 1 since the majority of risks are posed by other CPCs.
- The only PCB with positive carcinogenicity results is Aroclor-1260. The carcinogenicity of all PCB isomers were assumed to be equal to the carcinogenicity of Aroclor-1260 because the dose-response data for other isomers are inconclusive. Statistically significant cancer results were not seen for Aroclors with lower percentages of chlorination. The conservatism introduced in the evaluation of PCBs is not anticipated to impact the selection of CPCs for final risks because they did not exceed the concentration-toxicity screen.
- As with PAHs, the carcinogenicity of dioxins and furans other than the 2,3,7,8-isomer were determined using EPA's revised Toxicity Equivalency Factors (TEFs) (EPA 1990d) in the absence of toxicity values for the different isomers (EPA, 1990d). The TEFs are

based on the assumption that all dioxin and furan congeners are carcinogenic. This may
introduce a large bias to the results of the assessment.

A significant source of uncertainty for calculating risks from radionuclides in surface soil is the use of
EPA slope factors for external radiation exposure. In deriving these slope factors, EPA has assumed
that an individual continuously stands on an infinitely thick slab of soil with a uniform radionuclide
concentration. To manage complicated calculations for photon attenuation and scattering in soil, EPA
has assumed that the activity in the slab source is present on an infinite plane with uniform surface
concentration. The slope factors for external radiation exposure are, therefore, based on calculated
exposures (and associated risks of cancer incidence) from the hypothetical plane source.

In addition, EPA calculates slope factors for ingestion of many radionuclides using the maximum
value for the GI absorption factor. The actual chemical form(s) that influence the magnitude of the GI
absorption factor have not been considered.

To summarize, the uncertainty associated with the toxicity assessment is chemical-specific since it
depends on the existing information used to derive the dose-response factor. In general, this
uncertainty tends to be more high (overestimate risks by two or more orders of magnitude) for the
chemical risk assessment, but tends to be low (overestimate risks by an order or magnitude or less) for
radionuclides. This difference is the result of animal versus human data used for chemical and
radiological compounds, respectively.

E.6.2.4 Risk Characterization

Uncertainty in risk characterization results from assumptions made regarding additivity of effects from
exposure to multiple compounds from various exposure routes. High uncertainty exists when summing
cancer risks or hazard indices for several substances across different exposure pathways. This assumes
that each substance has a similar effect and/or mode of action. Often compounds affect different
organs, have different mechanisms of action, and differ in their fate in the body where additivity is not
appropriate. However, the assumption of additivity is made to provide a conservative estimate of risk.

Risk characterization does not consider antagonistic or synergistic effects. Little to no information is
available to determine the potential for antagonism or synergism for CPCs. Therefore, this uncertainty
cannot be discussed based on the impact on the risk assessment since it has the potential to either
over-or under-estimate potential human health risks.

The additivity of risks from radionuclides and chemical carcinogens is the subject of considerable
debate. EPA guidance (EPA 1989a) indicates that the two sets of estimates should be considered
separately because 1) chemical CSFs are developed using laboratory experiments and radionuclide
toxicity values are based on human epidemiological data, and 2) chemical CSFs represent an upper

bound limit value while radionuclide slope factors are "best estimates." Therefore, cancer risks from exposure to radionuclides are presented separately from those from chemical CPCs.

E.6.3 SUMMARY OF UNCERTAINTIES IN OPERABLE UNIT 1 BASELINE RISK ASSESSMENT

Uncertainties encountered during the preparation of this assessment vary from waste pit to waste pit because their individual physical and chemical characterizations vary. While many of the uncertainties listed in these tables are shared between operable units, others are limited to a few of the waste pits. Table E.6-1 presents a qualitative evaluation of the uncertainties described in the preceding sections.

Although uncertainties arise from many sources, those deriving from the toxicity assessment (i.e., determination of dose-response factors) provide the greatest uncertainty for the chemical risk assessment because few chemical dose-response factors are based on human epidemiological studies. Thus, extrapolations from animal studies must be made. For the radiological assessment, the greatest uncertainty arises from the exposure assessment where exposure point concentration are often based on the maximum reported analytical result, and where conservative assumptions were made regarding future land uses and exposure scenarios. Unlike chemical toxicity data, radiological dose-response factors are derived from human studies which is assumed to result in lower uncertainty.

Generally, uncertainty arises wherever data gaps exist. Data gaps in the risk assessment were mitigated by making conservative assumptions for individual parameters. Significant uncertainty results for those particular pathways that required fate and transport modeling to support the assessment of exposure. Such uncertainty was generated for the air and groundwater pathways of exposure. Thus, interpretation of risk from these media must consider the high uncertainty. Also, certain exposure pathways for a particular medium tend to have higher or lower uncertainty depending on their assumptions. For example, incidental ingestion of soils by residents tends to have significantly less uncertainty than ingestion of fruits and vegetables, and meat and milk raised on contaminated soils. These latter exposure pathways must make some assumptions regarding their uptake from soil to plant and plant to live stock while the soil ingestion pathway does not.

Receptors with the highest uncertainty in the current source term are the off-property resident farmer and off-property user of meat/milk from livestock grazed on site. The off-property resident farmer scenario is evaluated based on modeled concentrations for the air pathway and results in high uncertainty. The bioaccumulation of CPCs into meat/milk are modeled, and as a result, provide moderate to high uncertainty for this receptor. The greatest uncertainty in the risk assessment of Operable Unit 1 is associated with the assumptions made in the future source. These particular receptors include the on-property resident farmer, Great Miami River user, and off-property user of meat and milk. For the on-property resident farmer and home builder, the highest uncertainty is associated with the proposed land used and potential exposure pathway. This receptor scenario is

included in response to guidance and is anticipated to have a low likelihood of occurrence due to the history of the site and the particular waste management activities within Operable Unit 1. Uncertainty associated with the off-property resident farmer and Great Miami River water user is primarily the result of surface water and air modeling used to support those scenarios. The modeling assumptions are conservative, which result in conservative estimates for the exposure point concentrations.

Taken together, the uncertainties identified with site data, exposure parameters, fate and transport, toxicity assessment and risk characterization are judged to be high (i.e., potential to over-estimate risk by two or more orders of magnitude).

4282

TABLE E.6-1
UNCERTAINTIES ASSOCIATED WITH ESTIMATED RISKS FROM OPERABLE UNIT 1

Source of Uncertainty	Magnitude ^a	Expected Direction ^b	Remark
<u>Selection of CPCs:</u>			
• Adequacy of database	Low	Increases or decreases conservatism	CPCs may be underestimated. Principal constituents were identified.
<u>Exposure Assessment:</u>			
• Calculated exposure point concentrations - positive bias in sampling	Moderate	Increases conservatism	Source concentrations based on 95% UCL or maximum. Sampling was biased for radiological CPCs
- conservative modeling assumptions	High	Increases conservatism	Modeled concentrations were conservative.
• Determination of land uses - current scenario - future scenario	Low High	Increases conservatism Increases conservatism	Scenario based on current environmental setting Worst case scenario assumed.
• Assumptions for source terms - current source term	Low	Increases or decreases conservatism	Current source term assumes waste pits covered and surface water runoff treated.
- future source term	Moderate	Increases conservatism	Future source term assumes failure of Waste Pit 3 cap.
• Selection of receptors - current scenario - future scenario	Low High	Increases conservatism Increases conservatism	Scenario based on current environmental setting. Worst case scenario assumed.
• Determination of exposure factors	Low to moderate	Increases conservatism	Receptor and exposure pathway specific.

E-6-1-16

0697

TABLE E.6-1
(Continued)

Source of Uncertainty	Magnitude ^a	Expected Direction ^b	Remark
<u>Toxicity Assessment:</u>			
• Dose-response assessment			
- chemical CPCs	High	Increases conservatism	Dose-response based on animal data.
- radiological CPCs			
internal	Low	Increases conservatism	Dose-response based on human data.
external	Moderate to high	Increases conservatism	Conservative assumptions made for external exposure.
• Other OUI CPCs			
- dose-response for PAHs	Low	Increases conservatism	PAHs pose low risk.
- dose-response for PCBs	Low	Increases conservatism	PCBs pose relatively low risk.
- dose-response for dioxins/furans	Low	Increases conservatism	Furans/dioxins relatively low risk.
- dose-response for Rn-222 (indoors)	Low to moderate	Increases conservatism	Assumptions for indoor Rn-222 differ from those made for the CSF.
<u>Risk Characterization:</u>			
• Additivity	Low to moderate	Increases conservatism	Health effects dominated from few CPCs and exposure pathways.
• Failure to consider antagonism	Unknown	Increases conservatism	Data unknown.
• Failure to consider synergism	Unknown	Decreases conservatism	Data unknown.
• Failure to consider segregation of HIs	Low	Increases conservatism	HIs dominated by few CPCs and exposure pathways.
<u>Overall</u>	High	Increases conservatism	High uncertainty from combining low, moderate, and highly uncertain parameters.

^aMagnitude is assessed qualitatively based on professional judgment and includes the following:

Low-impact risk by a factor of 10 or less.

Moderate-impact risk by a factor of 10 to 100.

High-impact risk by a factor of 100 or more.

^bDirection is assessed qualitatively where an increased conservatism increases final health effects and a decreased conservatism decreases final health effects calculated in risk assessment.

E.7.0 SUMMARY AND COMPARISON TO BACKGROUND

The baseline risk assessment was performed in accordance with available EPA guidance and follows the guidelines for performing risk assessments at the FEMP, as described in the Risk Assessment Work Plan Addendum (DOE 1992a). This section contains a summary of the Baseline Risk Assessment in Section E.7.1 and information on risks associated with natural (background) soils in Section E.7.2.

E.7.1 RISK ASSESSMENT SUMMARY

Radionuclides detected most frequently above background levels within Operable Unit 1 include U-238, U-234, U-235, Ra-226, Rn-222, Th-232, Th-230, Th-228, and Tc-99. Metals detected above background levels, and therefore retained as constituents of potential concern (CPCs), include arsenic, cadmium, chromium, cobalt, lead, nickel, and uranium. Organic constituents evaluated in the quantitative risk assessment include polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), tetrachloroethene, and benzene.

Potential human health effects, calculated for OU1, were evaluated based on the range of acceptable risk under CERCLA. These acceptable risk ranges are an ILCR of 10^{-6} to 10^{-4} and an HI of less than 1 (EPA 1992d). In general, estimated cancer risks associated with the scenarios involving current chemical concentrations and continued access controls are in the range of 10^{-6} to 10^{-4} . However, for the scenarios that assume access control will be lost, or for those scenarios that assume exposures to calculate future concentrations, ILCRs are generally greater than 10^{-4} and most HIs are greater than 1. In fact, the total calculated ILCRs associated with chemical exposures by the on-property RME resident adult are about 1×10^{-1} (1 in 10 chance of developing cancer) for the future land use scenario.

Carcinogenic risks and Hazard Indices for identified receptors under current land use and current source term conditions are summarized in Tables E.7-1 and E.7-2, respectively. The receptors associated with this scenario were identified based on consideration of site access controls. The visitor and off-property RME resident farmer were considered applicable for consideration with current access controls. The receptors considered applicable if access controls were removed are the trespassing child, off-property RME resident farmer and off-property user of meat and dairy products (i.e., an individual that would ingest meat and dairy products from livestock grazed on site). With access controls, the exposure pathway contributing the greatest risk is inhalation of dust containing radiological constituents (i.e., Th-230, U-238, and U-234). Under current land use without access controls the principle exposure pathways from the current source term are biotransfer of chemical CPCs into dairy products and beef, inhalation of dusts containing radiological compounds (off-property RME resident farmer) and penetrating gamma radiation exposure (trespassing child). The receptor with the greatest risk is the off-property use of meat and dairy

products from cows grazed on site would experience total carcinogenic risks of 3×10^{-3} . The primary contributors to this risk are Aroclor-1254 and arsenic in the surface soil and their biotransfer to meat and milk. The Hazard Indices for all these receptors are acceptable (less than 1). Metals (especially zinc) are the most significant systemic toxins.

Tables E.7-3 and E.7-4 contains a summary of risks associated with the future source term conditions, current and future land uses. Assumptions were made for the future source term regarding the configuration of the operable unit that would result in higher exposure to stored waste materials. Two scenarios were evaluated, the current land use scenario without access controls and a future scenario that assumes development of the operable unit for resident and farm (raising livestock and growing crops). For the current land use scenario, (assumes residence is not built onsite) cancer risks range from 3×10^{-7} to 2×10^{-3} for radionuclides and from 2×10^{-4} to 4×10^{-3} for chemical carcinogens. The maximum risk was to the off-property RME resident farmer with inhalation of dusts and ingestion of beef and dairy products contributing the greatest to their total risk. Potential risk to the Great Miami River user were less than 10^{-6} .

Receptors with the highest risk from the future source term and future land use are the on-property RME resident farmer (carcinogenic assessment) and on-property RME child (noncarcinogenic assessment). The exposure pathway making the largest single contribution to the overall risk is ingestion of well water from the Great Miami River Aquifer for both radiological and chemical carcinogens and for chemical systemic toxicants.

Other routes of exposure for this receptor include inhalation of dust, ingestion of food products affected by aerial deposition, penetrating radiation from surface soils and buried pit material, direct contact with soil and exposed pit material, domestic and agricultural use of groundwater, and ingestion of meat and dairy products from cows grazed and watered on site. Total radiocarcinogenic and chemical carcinogenic risks are approximately 1×10^{-1} for all these routes of exposure combined. Individually, ingestion of groundwater containing metals (arsenic) and U-238 contributes almost half of this receptor's total risk followed by external exposure to surface soils and buried pit materials and inhalation of dust. Uranium and thorium isotopes and arsenic are the major carcinogens for these exposure pathways.

Routine consumption of the perched water by the RME resident farmer (a highly unlikely scenario given the low yield of this water and the shallow depth of a more reliable, better quality aquifer) presents a cancer risk of 5×10^{-1} from U-238 and 1×10^{-1} from arsenic.

E.7.2 RISKS FROM NATURAL BACKGROUND

All site-related risks in the risk assessment are calculated without accounting for the contribution from natural background. In many cases, the concentrations of CPCs in the soil at the OU1 waste pits are only slightly above natural background concentrations, but the ILCRs or HIs for these site-related

concentrations are often greater than 10^{-4} and 1 respectively. Background contributions provide a useful point of comparison for site-related risk estimates.

Risks and hazard quotients are calculated for background concentrations of CPCs in soil. These results are presented in Tables E.7-5 and E.7-6. Exposure assumptions and models used for these background calculations are the same as those used for evaluating site-related risks to the RME on-property resident farmer. Soil concentrations used for background risk calculations are the UCL values determined for the site-specific background soil sample analytical results.

Background risks from radionuclides and their short-lived progeny are 2×10^{-3} . The health risk attributable to the naturally occurring radioactive isotope of potassium, K-40, is slightly larger (within the same order of magnitude) than all other radioisotopes combined. The risk from K-40 was not included in the total risk because K-40 was not selected as a CPC for this operable unit. Including it in the total risk from background could bias decisions if the total background risk were compared directly with the total site-related risks calculated in this report. It is included separately because it is a ubiquitous component of background. Discounting the contribution from K-40, the exposure pathway that contributes nearly all of this risk is external radiation exposure from Ra-226, Th-228, and Ra-228 (and their short-lived progeny) in surface soil. It is important to note that the overall lifetime risk, as calculated by CERCLA methodology, from natural background radiation sources (such as cosmic radiation, primordial radionuclides in surface soil, and radon) is approximately 1×10^{-2} . Background risks from arsenic and beryllium in soil at background concentrations also exceed 1×10^{-4} .

Background Hazard Quotients were calculated for natural background concentrations of inorganic chemicals in soil. Results of these calculations for the RME on-property resident adult are given in Table E-7.4. Again, the soil concentrations used are the site-specific background soil sample analytical results UCLs. The Hazard Index for background concentrations of inorganics is 8. The HQs estimated using the background UCLs and the methodology described in Section E.1 through E.5 exceed 0.1 for five metals (arsenic, boron, cadmium, manganese, and thallium), and the HQ for natural background levels of mercury exceeds 1.0. The results of the background risk calculation and the potential for toxic effects to occur from natural background concentrations of radionuclides and inorganic chemicals suggest that the risk assessment methodology has a conservative bias.

E.7.3 CONCLUSIONS

This appendix presents the results of the baseline risk assessment for each of the waste pits in Operable Unit 1. The methods, models, and parameters that have been used are in accordance with the Risk Assessment Work Plan Addendum (DOE 1992a), with exceptions noted in the text preceding sections of this appendix.

4782

The emphasis on identifying potential uncertainties in Section E.6.0 of the risk assessment is not intended to discredit the calculation results, but to emphasize that conservative assumptions have been made whenever there is a lack of information or the information is incomplete. Refinement of waste pit characterization data, exposure assessment models and parameters, and risk characterization information will reduce these uncertainties.

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TABLE E.7-1

**INCREMENTAL LIFETIME CANCER RISK SUMMARY
CURRENT SOURCE TERM**

Media	Visitor	Off-Property RME Resident Farmer	Trespassing Child	Off-Property User of Meat and Dairy Products
Air				
Radiocarcinogenic risk	1×10^{-4}	6×10^{-5}	1×10^{-5}	NA ^a
Chemical carcinogenic risk	3×10^{-6}	3×10^{-6}	4×10^{-7}	NA
Total ^b	1×10^{-4}	6×10^{-5}	1×10^{-5}	NA
Buried Pit Material				
Radiocarcinogenic risk	9×10^{-5}	NA	2×10^{-5}	NA
Chemical carcinogenic risk	NA	NA	NA	NA
Total ^b	9×10^{-5}	NA	2×10^{-5}	NA
Surface Soil				
Radiocarcinogenic risk	8×10^{-4}	NA	2×10^{-5}	6×10^{-4}
Chemical carcinogenic risk	NA	NA	2×10^{-5}	2×10^{-3}
Total ^b	8×10^{-4}	NA	4×10^{-5}	3×10^{-3}
Surface Water				
Radiocarcinogenic risk	NA	NA	NA	4×10^{-5}
Chemical carcinogenic risk	NA	NA	NA	7×10^{-6}
Total ^b	NA	NA	NA	5×10^{-5}
All Media				
Radiocarcinogenic risk	9×10^{-4}	6×10^{-5}	5×10^{-5}	6×10^{-4}
Chemical carcinogenic risk	3×10^{-6}	3×10^{-6}	2×10^{-5}	2×10^{-3}
Total ^b	9×10^{-4}	6×10^{-5}	7×10^{-5}	3×10^{-3}

^aNA - Not applicable. Exposure route not evaluated.

^bRadiocarcinogenic and chemocarcinogenic risks are not truly additive. Provided for reference only.

TABLE E-7-2

HAZARD INDEX SUMMARY
CURRENT SOURCE TERM

Media	Visitor	Off-Property RME Resident Farmer	Trespassing Child	Off-Property User of Meat and Dairy Products
Air	0.5	0.07	0.1	NA
Buried Pit Material	NA	NA	NA ^a	NA
Surface Soil	NA	NA	0.1	7
Surface Water	NA	NA	NA	4
Total - All Media	0.5	0.07	0.2	11

^aNA - Not applicable. Exposure route not evaluated.

E7-1-6 0704

TABLE E.7-3

**INCREMENTAL LIFETIME CANCER RISK SUMMARY
FUTURE SOURCE TERM**

	Current Land Use				Future Land Use			
	Trespassing Child	Off-Property RME Resident Farmer	Great Miami River User	Off-Property User of Meat and Milk	On-Property RME Adult Farmer	On-Property CT Adult Farmer	On-Property RME Child	Home Builder
Air								
Radiocarcinogenic Risk	2×10^{-4}	9×10^{-4}	NA ^a	NA	1×10^{-2}	9×10^{-4}	2×10^{-4}	2×10^{-5}
Chemical Carcinogenic Risk	1×10^{-4}	4×10^{-3}	NA	NA	1×10^{-2}	9×10^{-4}	4×10^{-3}	8×10^{-4}
Total ^b	3×10^{-4}	5×10^{-3}	-	-	2×10^{-2}	2×10^{-3}	4×10^{-3}	3×10^{-3}
Buried Pit Material								
Radiocarcinogenic Risk	7×10^{-6}	NA	NA	NA	1×10^{-3}	2×10^{-4}	2×10^{-7}	3×10^{-6}
Chemical Carcinogenic Risk	NA	NA	NA	NA	NA	NA	NA	NA
Total ^b	7×10^{-6}	-	-	-	1×10^{-3}	2×10^{-4}	2×10^{-7}	3×10^{-6}
Surface Soil/Exposed Pit Material								
Radiocarcinogenic Risk	3×10^{-4}	NA	NA	6×10^{-4}	2×10^{-2}	4×10^{-3}	3×10^{-3}	2×10^{-6}
Chemical Carcinogenic Risk	1×10^{-4}	NA	NA	2×10^{-3}	1×10^{-2}	1×10^{-3}	7×10^{-3}	5×10^{-4}
Total ^b	4×10^{-4}	-	-	3×10^{-3}	3×10^{-2}	5×10^{-3}	1×10^{-2}	5×10^{-4}
Sediment								
Radiocarcinogenic Risk	5×10^{-6}	NA	NA	NA	NA	NA	NA	NA
Chemical Carcinogenic Risk	2×10^{-5}	NA	NA	NA	NA	NA	NA	NA
Total ^b	3×10^{-5}	-	-	-	-	-	-	-
Groundwater								
Radiocarcinogenic Risk	NA	7×10^{-4}	NA	NA	9×10^{-3}	6×10^{-4}	6×10^{-4}	NA
Chemical Carcinogenic Risk	NA	0	NA	NA	4×10^{-2}	3×10^{-3}	1×10^{-2}	NA
Total ^b	-	7×10^{-4}	-	NA	5×10^{-2}	4×10^{-3}	1×10^{-2}	NA
Surface Water								
Radiocarcinogenic Risk	NA	NA	3×10^{-7}	4×10^{-5}	4×10^{-5}	2×10^{-6}	8×10^{-6}	NA
Chemical Carcinogenic Risk	NA	NA	0	7×10^{-6}	7×10^{-6}	5×10^{-7}	2×10^{-6}	NA
Total ^b	-	-	3×10^{-7}	5×10^{-5}	5×10^{-5}	3×10^{-6}	1×10^{-5}	NA

TABLE E.7-3
(Continued)

	Current Land Use				Future Land Use			
	Trespassing Child	Off-Property RME Resident Farmer	Great Miami River User	Off-Property User of Meat and Milk	On-Property RME Adult Farmer	On-Property CT Adult Farmer	On-Property RME Child	Home Builder
Perched Water								
Radiocarcinogenic Risk	NA	NA	NA	NA	5×10^{-1}	5×10^{-2}	4×10^{-2}	NA
Chemical Carcinogenic Risk	NA	NA	NA	NA	1×10^{-1}	1×10^{-2}	4×10^{-2}	NA
Total ^b	NA	NA	NA	NA	6×10^{-1}	6×10^{-2}	8×10^{-2}	NA
All Pathways ^a								
Radiocarcinogenic Risk	5×10^{-4}	2×10^{-3}	3×10^{-7}	6×10^{-4}	4×10^{-2}	1×10^{-2}	4×10^{-3}	3×10^{-5}
Chemical Carcinogenic Risk	2×10^{-4}	4×10^{-3}	0	2×10^{-3}	7×10^{-2}	4×10^{-3}	2×10^{-2}	5×10^{-4}
Total ^b	7×10^{-4}	6×10^{-3}	3×10^{-7}	3×10^{-3}	1×10^{-1}	2×10^{-2}	2×10^{-2}	6×10^{-4}

^aNA - Not applicable. Exposure route not evaluated.

^bRadiocarcinogenic and chemical risks not readily summable. Provided for reference only.

^cTotals do not include ingestion of perched water.

4282

E.7-1-8

0706

TABLE E.7-4

HAZARD INDEX SUMMARY
FUTURE SOURCE TERM

	Current Land Use				Future Land Use			
	Trespassing Child	Off-Property RME Resident Farmer	Great Miami River User	Off-Property User of Meat and Milk	On-Property RME Adult Farmer	On-Property CT Adult Farmer	On-Property RME Child	Home Builder
Air	0.8	50	NA ^a	NA	330	180	1700	0.6
Buried Pit Material	NA	NA	NA	NA	NA	NA	NA	NA
Surface Soil/Exposed Pit Material	3	NA	NA	7	60	20	230	90
Sediment	0.7	NA	NA	NA	NA	NA	NA	NA
Groundwater	NA	10	NA	NA	270	140	940	NA
Surface Water	NA	NA	0	4	4	3	160	NA
Perched Water	NA	NA	NA	NA	6000	3100	17,000	NA
Total - All Media ^b	5	60	0	11	670	340	3100	90

^aNA - Not applicable. Exposure route not evaluated.^bTotals do not include ingestion of perched water.

TABLE E.7-5

**INCREMENTAL LIFETIME CANCER RISKS FOR SOIL PATHWAYS
RME RESIDENT FARMER
NATURAL BACKGROUND CONCENTRATIONS**

Radionuclide	0"-6" UCL Background Soil Concentration ^a (pCi/g)	Background Risk	Cancer Risks Operable Unit 1
Cs-137 + 1 dtr	4.4×10^{-1}	4×10^{-5}	4×10^{-4}
Ra-226 + 8 dtrs	1.2×10^0	3×10^{-4}	1×10^{-2}
Th-230	1.5×10^0	1×10^{-7}	1×10^{-4}
Th-232 + 10 dtrs	1.1×10^0	4×10^{-4}	2×10^{-2}
U-234	1.0×10^0	3×10^{-7}	3×10^{-5}
U-235 + 1 dtr	8.8×10^{-2}	9×10^{-7}	4×10^{-4}
U-238 + 2 dtrs	1.1×10^0	2×10^{-6}	1×10^{-3}
K-40 ^d	1.7×10^1	1×10^{-3d}	NA
Total Risk	--	7×10^{-4d}	4×10^{-2}

Chemical	0"-6" UCL Background Soil Concentration ^b (mg/kg)	Background Risk	Cancer Risks Operable Unit 1
Arsenic	6.0×10^0	2×10^{-4}	1×10^{-2}
Beryllium ^c	6.0×10^{-1}	2×10^{-4}	1×10^{-3}
Total Risk	--	4×10^{-4}	1×10^{-2}

^aRadionuclide UCL background concentrations in soil (0"-6") are obtained from Attachment E.I,

Table E.I-5.

^bChemical UCL background concentrations in soil (0"-6") are obtained from Attachment E.I, Table E.I-4.

^cUCL was not calculated; frequency of detection was 1/30.

^dThe background risk for K-40 was not included in total background risk because K-40 was not

selected as a CPC for this operable unit. Including it in the total risk from background could bias decisions if the total background risk were compared directly with the total site-related risks calculated in this report. It is included here because it is a ubiquitous component of background.

4787

TABLE E.7-6
TOXIC EFFECTS FOR SOIL PATHWAYS
RME RESIDENT FARMER
NATURAL BACKGROUND CONCENTRATIONS

Chemical	0"-6" UCL Background Soil Concentration ^a (mg/kg)	Background Hazard Quotient	Hazard Quotients Operable Unit 1
Arsenic	6.0×10^0	0.4	26
Beryllium ^b	6.0×10^{-1}	0.009	0.05
Barium	7.9×10^0	0.04	0.1
Boron	1.2×10^1	0.5	0.004
Cadmium	4.0×10^{-1}	0.1	1.5
Chromium	1.2×10^1	0.008	0.06
Cobalt	1.1×10^1	0.008	0.009
Manganese	9.8×10^2	0.9	0.8
Mercury ^b	3.0×10^{-1}	6	0.04
Molybdenum	ND ^c	--	0.2
Nickel	1.3×10^1	0.08	0.1
Silver	ND	--	3
Thallium ^b	5.8×10^{-1}	0.3	0.2
Uranium ^d	2.3×10^0	0.02	5
Vanadium	2.2×10^1	0.03	0.6
Total Hazard Index	--	8	38

^aChemical UCL background concentrations in soil (0"-6") are obtained from Attachment E.I,

Table E.I-4.

^bUCL was not calculated; frequency of detection was 1/30 and maximum is presented.

^cND - Not detected.

^dTotal uranium arithmetic mean background concentration in soil is obtained from Table 4-9 of the

CERCLA/RCRA Background Soil Study (March 19, 1993).

0709

REFERENCES

ASI/IT, March 1988, "Remedial Investigation and Feasibility Study, FEMP, Fernald, Ohio, Work Plan," Vols. 1 through 5, ASI/IT, Ross, Ohio.

Aaseth, J. and T. Norseth, 1986, "Copper," Handbook on the Toxicology of Metals, Vol. II, L. Friberg, G. F. Nordberg, and V. B. Vouk, eds., Elsevier Science Publishers B. V., New York, pp. 233-254.

Abbatt, J. D., 1973, "Human Leukemic Risk Data Derived from Portuguese Thorotrast Experience," Radionuclide Carcinogenesis, CONG-72055, C. D. Sander, R. H. Busch, J. E. Ballou, and J. E. Mahlum, eds., U.S. Atomic Energy Commission, Washington, DC, pp. 451-464.

Agency for Toxic Substances and Disease Registry (ATSDR), 1987, Toxicological Profile for Benzo[a]Pyrene, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1988a, Toxicological Profile for Nickel, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1988b, Toxicological Profile for Tetrachloroethylene, Draft for Public Comment, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1989a, Toxicological Profile for Benzene, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1989b, Toxicological Profile for Carbon Tetrachloride, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1989c, Toxicological Profile for Chlordane, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1989d, Toxicological Profile for p,p'-DDT, p,p'-DDE, p,p'-DDD, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1989e, Toxicological Profile for 2,3,7,8-Tetrachlorodibenzo-p-dioxin, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1989f, Toxicological Profile for 1,1-Dichloroethene, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1989g, Toxicological Profile for 1,1,2,2-Tetrachloroethane, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1989h, Toxicological Profile for Toluene, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1989i, Toxicological Profile for Vinyl Chloride, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1989j, Toxicological Profile for Cyanide, Draft, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1990a, Toxicological Profile for Polycyclic Aromatic Hydrocarbons: Acenaphthene, Acenaphthylene, Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(g,h,i)perylene, Chrysene, Dibenzo(a,h)anthracene, Fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Phenanthrene, Pyrene, Draft for Public Comment, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry, 1990b, Toxicological Profile for Plutonium, Draft for Public Comment, U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1991, Toxicological Profile for Selected PCBs (Aroclor-1260, -1254, -1248, -1242, -1232, -1221, and -1016), U.S. Public Health Service, Atlanta, GA.

Agency for Toxic Substances and Disease Registry (ATSDR), 1992, Toxicological Profile for Selected PCBs (Aroclor-1260, -1254, -1248, -1242, -1232, -1221, and -1016), U.S. Public Health Service, Atlanta, GA, (Draft for public comment).

Albro, P. W. and L. Fishbein, 1972, "Intestinal Absorption of Polychlorinated Biphenyls in Rats, Bull. Environmental Contamination and Toxicology, Vol. 8, pp. 26-31, (Cited in ATSDR 1991).

Allen, J. R., D. H. Norbach, and I. C. Hsu, 1974, "Tissue Modifications in Monkeys as Related to Absorption, Distribution, and Excretion of Polychlorinated Biphenyls," Archives of Environmental Contamination and Toxicology, Vol. 2, pp. 86-95, (Cited in ATSDR 1991).

Amano, M., K. Yagi, H. Nakajima, R. Takehara, H. Sakai, and G. Umeda, 1984, "Statistical Observations About the Causes of Death of Patients With Oil Poisoning," Japan, Hygiene, Vol. 49, pp. 1-5, (Cited in EPA 1988).

American Conference of Governmental Industrial Hygienists (ACGIH), 1986, Documentation of the Threshold Limit Values and Biological Exposure Indices, 5th ed., Cincinnati, OH.

American Conference of Governmental Industrial Hygienists (ACGIH), 1991, Documentation of the Threshold Limit Values and Biological Exposure Indices, 6th ed., Cincinnati, OH.

Andelman, J. B., 1990, Total Exposure to Volatile Organic Chemicals in Potable Water, N. M. Ram, R. F. Christman, K. P. Cantor, Eds., Lewis Publishers, Chelsea, MI.

Anderson, D. P., C. W. Beard, and R. P. Hanson, 1964, "The Adverse Effects of Ammonia on Chickens Including Resistance to Infection With Newcastle Disease Virus," Avian Diseases, Vol. 8, pp. 369-379, (Cited in EPA 1992).

Archer, V. E., J. K. Wagoner, and F. E. Lundin, 1973, "Cancer Mortality Among Uranium Mill Workers," Journal of Occupational Medicine, Vol. 15, pp. 11-14.

Baes, C. F., III and R. D. Sharp, 1983, "A Proposal for Estimation of Soil Leaching and Leaching Constants for Use in Assessment Models," Journal of Environmental Quality, Vol. 12, pp. 17-28.

Baes, C. F., III, R. D. Sharp, A. L. Sjoreen, and R. W. Shor, 1984, "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture," ORNL - 5786, Oak Ridge National Laboratory, Oak Ridge, TN.

Ballou, J. E., R. A. Gies, G. E. Dagle, M. D. Tolley, and A. C. Case, 1980, "Deposition and Late Effects of Inhaled $^{232}\text{UO}_2(\text{NO}_3)$ in Rats," PNL Annual Report 1980 (Biomedical Sciences) PNL-3700 P & L, Richland, WA, p. 142ff.

Barnett, J. R. and H. W. Dorough, 1974, "Metabolism of Chlordane in Rats," Journal of Agricultural and Food Chemistry, Vol. 22, pp. 612-619, (Cited in ATSDR 1989_).

Bensted, J. P. M., 1967, "Experimental Studies in Mice on the Late Effects of Radioactive and Nonradioactive Contrast Media," American New York Academy of Sciences, Vol. 145, pp. 728-733.

Benthe, H. F., J. Knop, and A. Schmoldt, 1972, "Absorption and Distribution of Polychlorinated Biphenyls (PCB) After Inhalatory Application," Archives of Toxicology, Vol. 29, pp. 85-95, [German], (Cited in ATSDR 1991).

Berlin, M., 1986a, "Mercury," Handbook on the Toxicology of Metals, Friberg, L., G. F. Nordberg and V. B. Vouk, eds., Vol. II, 2nd ed., Elsevier Science Publishers B. V., New York, pp. 387-445.

Berlin, M. and B. Rudell, 1986b, "Uranium," Handbook on the Toxicology of Metals, Friberg, L., G. F. Nordberg, and V. B. Vouk, eds., Vol. II, 2nd ed., Elsevier Science Publishers B. V., New York, pp. 623-637.

Berlin, M. and B. Rudell, 1979, "Uranium," Handbook on Toxicology of Metals, L. Friberg et al., eds., North-Holland Biomedical Press.

Bertazzi, P. A., L. Riboldi, A. Pesatori, et al., 1987, "Cancer Mortality of Capacitor Manufacturing Workers," American Journal of Industrial Medicine, Vol. 11, pp. 165-176, (Cited in EPA 1988, 1992a; ATSDR, 1991).

Bleavins, M. R., W. J. Breslin, R. J. Aulerich, et al., 1984, "Placental and Mammary Transfer of a Polychlorinated Biphenyl Mixture (Aroclor 1254) in the European Ferret (Mustela putorius furo)," Environmental Toxicology and Chemistry, Vol. 3, pp. 637-644, (Cited in ATSDR 1991).

Boquin, L., D. Shuwei, Y. Airu, X. YinLin, G. Taibao, and C. Tao, 1982, "Studies on the Toxicity of Allyl Chloride," Ecotoxicology and Environmental Safety, Vol. 6, pp. 19-27, (Cited in EPA, 1992).

Brown, D., K. R. Butterworth, I. F. Gaunt, P. Grasso, and S. D. Gangolli, 1978, "Short-term Oral Toxicity Study of Diethyl Phthalate in the Rat," Food and Cosmetic Toxicology, Vol. 16, pp. 415-422, (Cited in EPA 1992).

Brown, D. P., 1987, "Mortality of Workers Exposed to Polychlorinated Biphenyls: An Update," Archives of Environmental Health, Vol. 42, pp. 333-339, (Cited in EPA 1992a; ATSDR, 1991).

Brown, J. F. and R. W. Lawton, 1984, "Polychlorinated Biphenyl (PCB) Partitioning Between Adipose Tissue and Serum," Bulletin of Environmental Contamination and Toxicology, Vol. 33, pp. 277-280, (Cited in ATSDR 1991).

Budavari, S., Ed., 1989, The Merck Index, An Encyclopedia of Chemicals, Drugs, and Biologicals, 11th ed., Rahway, NJ: Merck and Co., Inc., p. 1517.

Buhler, F., P. Schmid, and C. H. Schlatter, 1988, "Kinetics of PCB Elimination in Man," Chemosphere, Vol. 17, pp. 1717-1726, (Cited in ATSDR 1991).

Cebrian, M. E., A. Albores, M. Aguilar, and E. Blakely, 1983, "Chronic Arsenic Poisoning in the North of Mexico," Human Toxicology, Vol. 2, pp. 121-133, (Cited in EPA 1992).

Chen, P. H., M. L. Luo, C. K. Wong, and C. J. Chen, 1982, "Comparative Rates of Elimination of Some Individual Polychlorinated Biphenyls from the Blood of PCB Poisoned Patients in Taiwan," Food Chemistry and Toxicology, Vol. 20, pp. 417-425, (Cited in ATSDR 1989).

Clayton, W. J., Jr., 1967, "Fluorocarbon Toxicity and Biological Action," Fluorine Chemistry Review, Vol. 1, pp. 197-252, (Cited in EPA 1992).

Clement International, 1990, "Development of Relative Potency Estimates for PAHs and Hydrocarbon Combustion Product Fractions Compared to Benzo[a]Pyrene and Their Use in Carcinogen Risk Assessments," prepared for the U.S. EPA, Washington, DC.

Clement, 1988, Comparative Potency Approach for Estimating the Cancer Risk Associated with Exposure to Mixtures of Polycyclic Aromatic Hydrocarbons. Interim Final Report. ICF - Clement Association, April 1988.

Cook, J. W., 1932, "The Production of Cancer by Pure Hydrocarbons -- Part II," Proceedings of the Royal Society of London S.B., Vol. 11, pp. 485-496, (Cited in EPA 1992).

Cookfair, D. L., W. L. Beck, C. Shy, C. C. Lushbaugh, and C. L. Sowder, 1983, "Lung Cancer Among Workers at a Uranium Processing Plant," Proceedings of the Health Physics Society, presented at Epidemiology Applied to Health Physics, pp. 398-406.

Couture, L. A., M. R. Elwell, and L. S. Birnbaum, 1988, "Dioxin-like Effects Observed in Male Rats Following Exposure to Octachlorodibenzo-p-dioxin (OCDD) During a 13-Week Study," Toxicology and Applied Pharmacology, Vol. 93, pp. 31-46.

Cueffey, J. L., R. L. Hayes, J. J. Rafter, E. E. Watson, and J. E. Carton, 1984, "Radiation Dosimetry and Chemical Toxicity Considerations for Tc-99," Health Physics, Vol. 46, No. 2 (February), pp. 418-422.

Dames and Moore, 1982, "Final Safety Analysis Report - FMPC Waste Storage Area," prepared for NLO, Inc., Cincinnati, OH.

Dames and Moore, 1985a, "Department of Energy Feed Materials Production Center, Groundwater Study - Task C Report," Dames & Moore, White Plains, NY, prepared for NLO, Inc., Cincinnati, OH.

Dames and Moore, 1985b, "Department of Energy Feed Materials Production Center, Groundwater Study - Task A Report," Dames & Moore, White Plains, NY, prepared for NLO, Inc., Cincinnati, OH.

de Motta, L. C., J. da Silva Horta, and M. H. Tavares, 1979, "Prospective Epidemiological Study of Thorotrast-Exposed Patients in Portugal," Environmental Research, Vol. 18, pp. 152-172.

Druckrey, H., H. Hamperl, and D. Schmahl, 1957, "Carcinogenic Action of Metallic Mercury After Intraperitoneal Administration in Rats," Zeitschrift Fur Krebsforschung und Klinische Onkologie, Vol. 61, pp. 511-519, (Cited in EPA 1992b).

Durbin, P. W. and M. E. Wrenn, 1975, "Metabolism and Effects of Uranium in Animals," M. E. Wrenn, ed., Conference on Occupational Health Experience with Uranium, ERDA-93, U.S. Energy Research and Development Administration, Washington, DC, pp. 67-129.

East, B. W., K. Boddy, E. D. Williams, D. MacIntyre, and A. L. McLay, 1980, "Silver Retention, Total Body Silver and Tissue Silver Concentrations in Argyria Associated with Exposure to an Anti-smoking Remedy Containing Silver Acetate," Clinical and Experimental Dermatology, Vol. 5, pp. 305-311, (Cited in EPA 1992).

Ecobichon, D. J., 1991, "Toxic Effects of Pesticides," Casarett and Doull's Toxicology, the Basic Science of Poisons, M. O. Amdur, J. Doull, and C. D. Klaassen, eds., 4th ed., Pergamon Press, New York, pp. 565-622.

Elinder, C. -G. and L. Friberg, 1986a, "Antimony," Handbook on the Toxicology of Metals, L. Friberg, G. F. Nordberg, and V. B. Vouk, eds., Vol. II, 2nd ed., Elsevier Science Publishers B. V., New York, pp. 26-42.

Elinder, C. -G and L. Friberg, 1986b, "Cobalt," Handbook on the Toxicology of Metals, L. Friberg, G. F. Nordberg, and V. B. Vouk, eds., Vol. II, Elsevier Science Publishers B. V., New York, pp. 211-232.

Elinder, C. -G., 1986c, "Zinc," Handbook on the Toxicology of Metals, L. Friberg, G. F. Nordberg, and V. B. Vouk, eds., Vol. II, 2nd ed., Elsevier Science Publishers B. V., New York, pp. 664-679.

Ely, T. S., 1959, "Medical Findings Summary," Symposium on Occupational Health Experience and Practices in the Uranium Industry, HASL-58, Office of Technical Services, Department of Commerce, Washington, DC.

Evans, R. D., A. T. Keane, F. J. Kolenkow, W. R. Neal, and M. M. Shanahan, 1969, "Radiogenic Tumors in the Radium and Mesothorium Cases Studied at M.I.T.," Delayed Effects of Bone-Seeking Radionuclides, C. W. Mays, W. S. S. Jee, R. D. Lloyd, B. J. Stover, J. H. Dougherty, and G. N. Taylor, eds., University of Utah Press, Salt Lake City, UT, pp. 157-194.

Evans, R. D., 1966, "The Effect of Skeletally Deposited Alpha-Ray Emitters in Man," British Journal of Radiology, Vol. 39, pp. 881-895.

Faber, M., 1973, Proceedings of the Third International Meeting on the Toxicity of Thorotrast, Riso Report, Danish Atomic Energy Commission, M. Faber, ed., Copenhagen, Denmark, pp. 137-147.

Faber, M., 1977, "Epidemiology of Thorotrast Malignancies in Man," Review Paper Prepared for the World Health Organization Scientific Group on the Long Term Effects of Radium and Thorium in Man, World Health Organization Working Paper 12, World Health Organization, Geneva, Switzerland.

Faber, M., 1978, "Malignancies in Danish Thorotrast Patients," Health Physics, Vol. 35, pp. 154-158.

Faber, M., 1979, "Twenty-eight Years of Continuous Follow-up of Patients Injected with Thorotrast for Cerebral Angiography," Environmental Research, Vol. 18, pp. 37-43.

Faber, M., 1983, "Current (1981) Status of the Danish Thorotrast Study," Health Physics, Vol. 44, Suppl. 1, pp. 259-260.

Faber, M., 1986, "Observations on the Danish Thorotrast Patients," Strahlentherapie, Vol. 80, pp. 140-142.

Facchetti, S., A. Formari, and M. Montagna, 1980, "Distribution of 2,3,7,8-Tetrachlorodibenzo-p-dioxin in the Tissues of a Person Exposed to the Toxic Cloud at Seveso (Italy)," Advances in Mass Spectrometry, Vol. 8B, pp. 1405-1414, (Cited in EPA 1985).

Falk, H., N. C. Telles, K. G. Ishak, L. B. Thomas, and H. Popper, 1979, "Epidemiology of Thorotrast-Induced Hepatic Angiosarcoma in the United States," Environmental Research, Vol. 18, pp. 65-73.

Federal Guidance Report No. 11 "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion": EPA-520-1-88-020, September 1988e.

Ferguson, W. S., W. C. Koch, L. B. Webster, and J. R. Gould, 1977, "Human Physiological Response and Adaptation to Ammonia," Journal of Occupational Medicine, Vol. 19, pp. 319-326, (Cited in EPA 1992).

Finkel, A. J., C. E. Miller, and R. J. Hasterlik, 1969, "Radium-Induced Malignant Tumors in Man," Delayed Effects of Bone-Seeking Radionuclides, J. Mays, R. D. Lloyd, B. J. Stover, J. H. Dougherty, and G. N. Taylor, eds., University of Utah Press, Salt Lake City, UT, pp. 195-225.

Fitzhugh, O. G., A. A. Nelson, E. P. Laug et al., 1950, "Chronic Oral Toxicities of Mercuri-phenyl and Mercuric Salts," Archives of Industrial Hygiene and Occupational Medicine, Vol. 2, pp. 433-442, (Cited in ATSDR 1989_).

Flury, K. E., D. E. Dines, J. R. Rodarte, and R. Rodgers, 1983, "Airway Obstruction Due to Inhalation of Ammonia," Mayo Clinic Proceedings, Vol. 58, pp. 389-393, (Cited in EPA 1992).

Food Research Laboratories, Inc., 1955, "Toxicological Studies of Diethyl Phthalate," Laboratory no. 67567, Celanese Corp. of America, Summit Research Laboratories, Summit, NJ, (Cited in EPA 1992).

Fowler, B. A. and G. F. Nordberg, 1986, "Silver," Handbook on the Toxicology of Metals, L. Friberg, G. F. Nordberg, and V. B. Vouk, eds., Vol. II, 2nd ed., Elsevier Science Publishers B. V., New York, pp. 521-531.

Friberg, L., T. Kjellström, and G. F. Nordberg, 1986, "Cadmium," Handbook on the Toxicology of Metals, Friberg, L., G. F. Nordberg, and V. B. Vouk, eds., Vol. II, 2nd ed., Elsevier Science Publishers B. V., New York, pp. 130-184.

Friberg, L. and J. Lener, 1986, "Molybdenum," Handbook on the Toxicology of Metals, L. Friberg, G. F. Nordberg, and V. B. Vouk, eds., Vol. II, Elsevier Science Publishers B. V., New York, p. 446-461.

Fries, G. F. and G. S. Marrow, 1975, "Retention and Excretion of 2,3,7,8-Tetrachlorodibenzo-p-dioxin by Rats," Journal of Agricultural and Food Chemistry, Vol. 23, pp. 265-269, (Cited in EPA 1985).

Gaffey, W. R., 1983, "The Epidemiology of PCBs," Ini D'Itri, F. M. and M. A. Kamrin, eds., PCBs: Human and Environmental Hazards, Butterworth Publishers, Boston, pp. 279-298.

Gadian, T., 1975, "Carcinogens in Industry, With Special Reference to Dichlorobenzidine," Chemistry and Industry, Vol. 4, pp. 821-831, (Cited in EPA 1992).

Gamble, M. R. and G. Clough, 1976, "Ammonia Build-up in Animal Boxes and Its Effect on Rat Tracheal Epithelium," Laboratory Animal, Vol. 10, pp. 93-104, (Cited in EPA 1992).

Gerarde, H. W. and D. F. Gerarde, 1974, "Industrial Experience With 3,3'-Dichlorobenzidine: An Epidemiological Study of a Chemical Manufacturing Plant," Journal of Occupational Medicine, Vol. 16, pp. 322-344, (Cited in EPA 1992).

Gerber, G. B., M. Hegela, J. VanKerkom, R. Kirchmann, J. R. Maisin, and M. Lambiet-cullire, 1989, "Technitium Dose to Man," Health Physics, Vol. 57, No. 2 (August), pp. 345-350.

Gilbert, R.O. of Van Nostrand Reinhold, 1992, Personal Communication with Show Hwa Fong of IT Corporation.

Gilbert, R.O., 1987, "Statistical Methods for Environmental Pollution Monitoring," Van Nostrand Reinhold, New York.

Goyer, R. A., 1991, "Toxic Effects of Metals," Casarett and Doull's Toxicology, the Basic Science of Poisons, M. O. Amdur, J. Doull, and C. D. Klaassen, eds., 4th ed., Pergamon Press, New York, pp. 623-680.

Gustavsson, P., C. Hogstedt, and C. Rappe, 1986, "Short-term Mortality and Cancer Incidence in Capacitor Manufacturing Workers Exposed to Polychlorinated Biphenyls," American Journal of Industrial Medicine, Vol. 10, pp. 341-344, (Cited in ATSDR 1991).

H&R (H&R Technical Associates, Inc.), 1986, "Draft Feed Materials Production Center Installation Assessment," FMPC-2049, prepared for U.S. Dept. of Energy, Weapons Division of Oak Ridge Operations, Oak Ridge, TN.

Harting, F. H. and W. Hesse, 1879, "Der Lungenkrebs, die Bergkrnkheit in den Schneeberger Gruben," Vierteljahrsschr. f. Gerichtl. Med. u. Offentl. Gensundheitswesen, Vol. 30, pp. 296-309, Vol. 31, pp. 102-132, 313-337.

Hausler, M. and R. Lenich, 1968, "Effect of Chronic Occupational Allyl Chloride Exposure," Archives of Toxicology, Vol. 23, pp. 209-214, (Cited in EPA 1992).

Hayes, M. A., 1987, "Carcinogenic and Mutagenic Effects of PCBs," S. Safe, ed., Environmental Toxin Series, Vol. A. Polychlorinated Biphenyls (PCBs): Mammalian and Environmental Toxicology, Springer-Verlag., New York, pp. 77-95.

Hayes, W., Ed., 1982, "Chlorinated Hydrocarbon Insecticides," Pesticides Studied in Man, Baltimore: Williams and Wilkins, pp. 186-195, (Cited in ATSDR 1989).

He, F., D. Shen, Y. Guo, and B. Lu, 1980, "Toxic Polyneuropathy Due to Chronic Allyl Chloride Intoxication: A Clinical and Experimental Study," Chinese Medical Journal, Vol. 93, pp. 177-182, (Cited in EPA 1992).

He, F., B. Lu, S. Zhang, S. Dong, A. Yu, and B. Wang, 1985, "Chronic Allyl Chloride Poisoning, An Epidemiology, Clinical, Toxicological and Neuropathological Study," Giornale Italiano Di Medicina Lavoro (Pavia), Vol. 7, pp. 5-15, (Cited in EPA 1992).

Högberg, J. and J. Alexander, 1986, "Selenium," Handbook on the Toxicology of Metals, L. Friberg, G. F. Nordberg, and V. B. Vouk, eds., Vol. II, 2nd ed., Elsevier Science Publishers B.V., New York, pp. 482-520.

Holness, D. L., J. T. Purdham, and J. R. Nethercott, 1989, "Acute and Chronic Respiratory Effects of Occupational Exposure to Ammonia," American Industrial Hygiene Association J., Vol. 50, pp. 646-650, (Cited in EPA 1992).

Horta, J. da Silva, M. E. Horta, L. C. da Motta, and M. H. Tavares, 1978, "Malignancies in Portuguese Thorotrast Patients," Health Physics, Vol. 35, pp. 137-152.

Howard, P. H., Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume I, Large Production and Priority Pollutants, Lewis Publishers, Chelsea, MI.

Hursch, J. B., W. R. Neuman, T. Toribara, H. Wilson, and C. Waterhouse, 1969, "Ingestion of Uranium by Man," Health Physics, Vol. 17, pp. 619-621.

Hursh, J. B. and N. L. Spoor, 1973, "Data on Man," Uranium, Plutonium and the Transuranic Elements, C. H. Hodge, J. N. Stannard, and J. B. Hursh, eds.,

Iffland, R., 1988, "Antimony," Handbook on Toxicity of Inorganic Compounds, Seiler, H. G., H. Sigel, and A. Sigel, eds., Marcel Dekker, Inc., New York, pp. 67-76.

International Agency for Research on Cancer (IARC), 1980, IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Vol. 23, Some Metals and Metallic Compounds, World Health Organization, Lyon, France, (Cited in EPA 1992).

International Agency for Research on Cancer (IARC), 1987, IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Overall Evaluations of Carcinogenicity: An Updating of IARC Monographs, Vols. 1 to 42, Preamble, Supplement 7, WHO: Lyon, France, pp. 17-34.

Ishinishi, N., K. Tsuchiya, M. Vahter, and B. A. Fowler, 1986, "Arsenic," Handbook on the Toxicology of Metals, L. Friberg, G. F. Nordberg, and V. B. Vouk, eds., Vol. II, 2nd ed., Elsevier Science Publishers B. V., New York, pp. 43-83.

IT Corporation (IT), 1986, "Final Interim Report - Air, Soil Water and Health Risk Assessment in the Vicinity of the FMPC, Fernald, OH." Report and Data Package prepared for the U.S. Department of Energy in Support of the Fernald Litigation, Oak Ridge Operations Office, Oak Ridge, TN.

Ito, N., H. Nagasaki, M. Arai et al., 1973, "Histopathologic Studies on Liver Tumorigenesis in Rats Treated with Polychlorinated Biphenyls and Its Promoting Effect on Liver Tumors Induced by Benzene Hexachloride," Journal of the National Cancer Institute, Vol. 51, pp. 1637-1646, (Cited in EPA 1992a).

Jacobson, J. L., G. G. Fein, S. W. Jacobson et al., 1984, "The Transfer of Polychlorinated Biphenyls (PCBs) and Polybrominated Biphenyls (PBBs) Across the Human Placenta and Into Maternal Milk," Journal of Public Health, Vol. 74, pp. 378-379, (Cited in ATSDR 1991).

Jensen, S. and G. Sundstrom, 1974, "Structures and Levels of Most Chlorobiphenyls in Two Technical PCB Products and In Human Adipose Tissue," Ambio, Vol. 3, pp. 70-76, (Cited in ATSDR 1991).

Jones, T. D. and B. A. Owen, 1989, "Health Risks from Mixtures of Radionuclides and Chemicals in Drinking Water," Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Kanisawa, M. and H. A. Schroeder, 1969, "Life Term Studies on the Effect of Trace Elements on Spontaneous Tumors in Mice and Rats," Cancer Research, Vol. 29, pp. 892-895, (Cited in EPA 1992).

Kazantzis, G., 1986, "Thallium," Handbook on the Toxicology of Metals, Friberg, L., G. F. Nordberg, and V. B. Vouk, eds., Vol. II, 2nd ed., Elsevier Science Publishers B. V., New York, pp. 549-567.

Kato, Y., T. Mori, and T. Kumatori, 1979, "Thorotrast Dosimetric Study in Japan," Environmental Research, Vol. 18, pp. 32-36.

Kato, Y., T. Mori, and T. Kumatori, 1983, "Estimated Absorbed Dose in Tissues and Radiation Effects in Japanese Thorotrast Patients," Health Physics, Vol. 44, Suppl. 1, pp. 273-279.

Kimbrough, R. D. and R. E. Linder, 1974, "Induction of Adenofibrosis and Hepatomas in the Liver of Balb/cJ Mice by Polychlorinated Biphenyls (Aroclor-1254)," Journal of the National Cancer Institute, Vol. 43, pp. 547-552, (Cited in EPA 1992a).

Kirwin, C. J. and E. E. Sandmeyer, 1981, "Ethers," Clayton, G. D. and F. E. Clayton, eds., Patty's Industrial Hygiene and Toxicology, Vol. II A, 3rd ed. revised, John Wiley and Sons, New York, pp. 2491-2565.

Knobloch, K., S. Szendzikowski, and A. Slusarczyk-Zalobona, 1969, "Acute and Subacute Toxicity of Acenaphthene and Acenaphthylene," Med. Pracy (Polish), Vol. 20, pp. 210-222, (Pol.) (Cited in EPA 1992a).

Kociba, R. J., D. G. Keyes, J. E. Bower, et al., 1978, "Results of a Two-year Chronic Toxicity and Oncogenicity Study of 2,3,7,8-Tetrachlorodibenzo-p-dioxin in Rats," Toxicology and Applied Pharmacology, Vol. 46, pp. 279-303, (Cited in EPA 1985, 1992b).

Kociba, R. J., P. A. Keeler, C. N. Park, and P. J. Gehring, 1976, "2,3,7,8-Tetrachlorodibenzo-p-dioxin Results of a 13-week Oral Toxicity Study in Rats," Toxicology and Applied Pharmacology, Vol. 35, pp. 553-573, (Cited in EPA 1985).

Kotin, P., et al., 1969, "Distribution, Retention and Elimination of c^{14} -3,4-Benzopyrene After Administration to Mice and Rats," Journal of the National Cancer Institute, Vol. 23, pp. 541, (Cited in EPA 1980a).

Krasavage, W. J., J. L. O'Donoghue, and G. D. Divincenzo, 1982, "Ketones," G. D. Clayton and F. E. Clayton, eds., Patty's Industrial Hygiene and Toxicology, 3rd ed. revised, Vol. 2C, John Wiley and Sons, New York, pp. 4747-4751; 4787-4800.

Krewski, D., T. Thorslund, and J. Withey, 1989, "Carcinogenic Risk Assessment of Complex Mixtures," Toxicology and Industrial Health, Vol. 5, pp. 851-867.

Kuwabara, K., T. Yakushiji, T. Watanabe et al., 1979, "Increase in the Human Blood PCB Levels Promptly Following Ingestion of Fish Containing PCBs," Bulletin of Environmental Contamination and Toxicology, Vol. 21, pp. 273-278, (Cited in ATSDR 1991).

Lagerkvist, B., G. F. Nordberg, and V. Vouk, 1986, "Vanadium," Handbook on the Toxicology of Metals, Friberg, L., G. F. Nordberg, and V. B. Vouk, eds., Vol. II, 2nd ed., Elsevier Science Publishers B. V., New York, p. 638-663.

Langård, S. and T. Norseth, 1986, "Chromium," Handbook on the Toxicology of Metals, Friberg, L., G. F. Nordberg, and V. B. Vouk, eds., Vol. II, Elsevier Science Publishers B. V., New York, pp. 185-210.

Laug, E. P., A. A. Nelson, O. G. Fitzhugh, and F. M. Kunze, 1950, "Liver Cell Alteration and DDT Storage in the Fat of the Rat Induced by Dietary Levels of 1-50 ppm DDT," Journal of Pharmacology and Experimental Therapy, Vol. 98, pp. 268-273, (Cited in EPA 1992).

LaVoie, E. J., S. Amin, S. S. Hecht, K. Furuya, and D. Hoffmann, 1982, "Tumor Initiating Activity of Dihydrodiols of Benzo[b]fluoranthene, Benzo[j]fluoranthene and Benzo[k]fluoranthene, Carcinogenesis," Vol. 3(1), pp. 49-52, (Cited in EPA 1992a).

Leach, L. J., E. A. Maynard, H. C. Hodge, J. K. Scott, C. L. Yuile, G. E. Sylvester, and H. B. Wilson, 1970, "A Five-Year Inhalation Study with Natural Uranium Dioxide (UO₂) Dust - I. Retention and Biologic Effect in the Monkey, Dog, and Rat," Health Physics, Vol. 18, pp. 599-612.

Leach, L. J., C. L. Yuile, H. C. Hodge, G. E. Sylvester, and H. B. Wilson, 1973, "A Five Year Inhalation Study with Natural Uranium Dioxide (UO₂) Dust - II. Postexposure Retention and Biologic Effects in the Monkey, Dog, and Rat," Health Physics, Vol. 25, pp. 239-258.

Lechel, D. J., 1986, "Unpublished Field Notes FMPC Site, 29 and 30 April, 1986," Roy F. Weston, Inc., Albuquerque, NM.

Leggett, R. W., 1989, "The Behavior and Chemical Toxicity of U in the Kidney: A Reassessment," Health Physics, Vol. 57, No. 3, pp. 365-383.

Leuschener, F., B. W. Neumann, and F. Hubscher, 1983, "Report on the Subacute Toxicological Studies with Several Fluorocarbons in Rats and Dogs by Inhalation," Arzneim-Forsch, Vol. 33, pp. 1475-1476, (Cited in EPA 1992).

Leussenhop, A. J., J. C. Gallimore, W. H. Sweet, E. G. Struxness, and J. Robinson, 1958, "The Toxicity in Man of Hexavalent Uranium Following Intravenous Administration," American Journal of Roentgenology, Vol. 79, pp. 83-100.

Lewtas, J., 1988, "Genotoxicity of Complex Mixtures: Strategies for the Identification and Comparative Assessment of Airborne Mutagens and Carcinogens from Combustion Sources," Fundamentals of Applied Toxicology, Vol. 10, pp. 571-589.

MacIntyre, I., 1975, "Experience of Tumors in a British Plant Handling 3,3'-Dichlorobenzidine," Journal of Occupational Medicine, Vol. 17, pp. 23-26, (Cited in EPA 1992).

Magos, L., 1986, "Tin" in Handbook on the Toxicology of Metals, Second Edition, Vol. II: Specific Metals, L. Friberg, G. F. Norberg, and V. B. Vouk, Eds., Elsevier Science Publishers, New York, pp. 568-593.

Marie, P. J., M. T. Garba, M. Holt and L. Mivavet, 1985, "Effects of Low Doses of Stable Sr on Bone Metabolism in Rats," Minerology Electrolyte Metabolism Vol. 11, pp. 5-13.

Marshall, J. H. and P. G. Groer, 1977, "A Theory of the Induction of Bone Cancer by Alpha Radiation," Radiation Research, Vol. 71, pp. 149-192.

Martland, H. S., 1931 "The Occurrence of Malignancy in Radioactive Persons," American Journal of Cancer, Vol. 15, pp. 2435-2516.

Martland, H. S., 1939, "Occupational Tumors, Bones," Encyclopedia of Health and Hygiene, International Labor Organization, Geneva, Switzerland.

Masuda, Y., R. Kagawa, H. Kuroki et al., 1978, "Transfer of Polychlorinated Biphenyls From Mothers to Fetuses and Infants," Food and Cosmetic Toxicology, Vol. 17, pp. 623-627, (Cited in ATSDR 1991).

Maynard, E. A. and H. C. Hodge, 1949, "Studies of the Toxicity of Various Uranium Compounds When Fed to Experimental Animals," The Pharmacology and Toxicology of Uranium Compounds, C. Voegtlin and H. C. Hodge, eds., Vol. 1.

Mays, C. W., R. E. Rowland, and A. F. Stehney, 1985, "Cancer Risk From the Lifetime Intake of Radium and Uranium Isotopes," Health Physics, Vol. 48, pp. 635-647.

Mays, C. W., 1973, "Cancer Induction in Man from Internal Radioactivity," Health Physics, Vol. 25, pp. 585-592.

Mays, C. W. and R. D. Lloyd, 1972, "Bone Sarcoma Incidence vs. Alpha Particle Dose," Radiobiology of Plutonium, B. J. Stover and W. S. S. Jee, eds., The J. W. Press, Salt Lake City, UT, pp. 409-430.

McConnell, E. E., G. W. Lucier, R. C. Rumbaugh, et al., 1984, "Dioxin in Soil: Bioavailability After Ingestion by Rats and Guinea Pigs," Science, Vol. 223, pp. 1077-1079, (Cited in EPA 1985).

McKone, T. E. and P. B. Ryan, 1989, "Human Exposure to Chemicals Through Food Chains: An Uncertainty Analysis," Environmental Science and Technology, Vol. 23, pp. 1154-1163.

Menzer, R. E., 1966, "Water and Soil Pollutants," Casarett and Doull's Toxicology, the Basic Science of Poisons, M. O. Amdur, J. Doull, and C. D. Klaassen, eds., 4th ed., Pergamon Press, New York, pp. 872-902.

Miller, S. E., D. A. Holiday, and H. N. Doyle, 1956, "Health Protection of Uranium Miners and Millers," Archives of Industrial Health, Vol. 15, pp. 48-55.

Mitsumori, K., K. Maita, T. Saito, S. Tsuda and Y. Shikasu, 1981, "Carcinogenicity of Methylmercury Chloride in ICR Mice: Preliminary Note on Renal Carcinogens," Cancer Letter, Vol. 12, pp. 305-310, (Cited in EPA 1992b).

Moeller, H. C. and J. A. Rider, 1962, "Plasma and Red Blood Cell Cholinesterase Activity as Indications of the Threshold of Incipient Toxicity of Ethyl-p-nitrophenyl Thionobenzenephosphorate (EPN) and Malathion in Human Beings," Toxicology and Applied Pharmacology, Vol. 4, pp. 123-130, (Cited in EPA 1992).

Moore, J. A., M. W. Harris, and P. W. Albro, 1976, "Tissue Distribution of (¹⁴C)Tetrachlorodibenzo-p-dioxin in Pregnant and Neonatal Rats," Toxicology and Applied Pharmacology, Vol. 37, pp. 146-147, (Cited in EPA 1985).

Mori, T., Y. Kato, T. Shimamine, and S. Watanabe, 1979a, "Statistical Analysis of Japanese Thorotrast-Administered Autopsy Cases," Environmental Research, International Meeting on the Toxicity of Thorotrast and Other Alpha-Emitting Heavy Elements, Lisbon, Portugal, Vol. 18, pp. 231-244.

Mori, T., T. Maruyama, Y. Kato, and S. Takahashi, 1979b, "Epidemiological Follow-up Study of Japanese Thorotrast Cases," Environmental Research, Vol. 18, pp. 44-54.

Mori, T., Y. Kato, T. Kumatori, T. Maruyama, and S. Hatakeyama, 1983, "Epidemiological Follow-up Study of Japanese Thorotrast Cases - 1980," Health Physics, Vol. 44, Suppl. 1, pp. 261-272.

Mori, T., T. Kumatori, Y. Kato, S. Hatakeyama, R. Kamiyama, W. Mori, H. Irie, T. Maruyama, and S. Iwata, 1986, "Present Status of Medical Study on Thorotrast-Administered Patients in Japan," Strahlentherapie, Vol. 80, pp. 123-134.

Murthy, G. K., U. Rhea, and J. T. Peeler, 1971, "Levels of Antimony, Cadmium, Chromium, Cobalt, Manganese, and Zinc in Institutional Total Diets," Environmental Science and Technology, Vol. 5, pp. 436-442, (Cited in EPA 1992).

Myrick, T. E., B. A. Berven, and F. F. Haywood, 1983, "Determination of Concentrations of Selected Radionuclides in Surface Soil in the U.S.," Health Physics, Vol. 45, pp. 631-642.

National Academy of Sciences (NAS), 1988, "Committee on the Biological Effects of Ionizing Radiations (BEIR IV), Health Risks of Radon and Other Internally Deposited Alpha-Emitters," National Academy of Sciences, National Academy Press, Washington, DC.

National Cancer Institute (NCI), 1978a, "Bioassay of Aroclor-1254 for Possible Carcinogenicity," NCI-GC-TR-38, NTIS PB279624, (Cited in EPA 1992a).

National Cancer Institute (NCI), 1978b, "Bioassay of Allyl Chloride for Possible Carcinogenicity," Carcinogenesis Technical Report Series, NCI-CG-TR-73, PB-287516, (Cited in EPA 1992).

National Cancer Institute (NCI), 1978c, "Bioassays of DDT, TDE, and p,p'-DDE for Possible Carcinogenicity," NCI Report No. 131, DHEW Publ. No. (NIH) 78-1386, (Cited in ATSDR 1989).

National Cancer Institute (NCI), 1978d, "Bioassay of Trichlorofluoromethane for Possible Carcinogenicity," Report No. 106, PHS/NIH, DHEW Publ. No. 78-1356, (Cited in EPA 1992).

National Council on Radiation Protection and Measurements (NCRP), August 31, 1991, "Some Aspects of Strontium Radiobiology," NCRP Report No. 110, National Council on Radiation Protection and Measurement, Bethesda, MD.

National Council on Radiation Protection and Measurements (NCRP), 1984, "Evaluation of Occupational and Environmental Exposures to Radon and Radon Daughters in the United States," NCRP Report 78, National Council on Radiation Protection and Measurement, Bethesda, MD.

National Council on Radiation Protection and Measurements (NCRP), 1984, "Radiological Assessment: Predicting the Transport, Bioaccumulation, and Uptake by Man of Radionuclides Released to the Environment," NCRP Report No. 76, National Council on Radiation Protection and Measurements, Washington, DC.

National Council on Radiation Protection and Measurement (NCRP), 1988, "Neptunium Radiation Protection Guidelines," NCRP Report No. 90.

National Council on Radiation Protection and Measurements (NCRP), 1989, "Screening Techniques for Determining Compliance with Environmental Standards," NCRP Commentary No. 3, National Council on Radiation Protection and Measurements, Washington, DC.

National Research Council (NRC), 1989, "Recommended Dietary Allowances," 10th ed., National Academy Press, Washington, DC.

8050

0721

4787

National Toxicology Program (NTP), 1980, Unpublished Subchronic Toxicity Study: Naphthalene (c52904), Fisher-344 Rats, Prepared by Battelle's Columbus Laboratories under subcontract No. 76-34-106002, (Cited in EPA 1992b).

Nau, H. and R. Bass, 1981, "Transfer of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) to the Mouse Embryo and Fetus," Toxicology, Vol. 20, pp. 299-308, (Cited in EPA 1985).

Nero, A. V., M. L. Boegel, C. D. Hollowell, J. G. Ingersoll, and W. W. Nazaroff, 1983, "Radon Concentrations and infiltration Rates Measured in Conventional and Energy-Efficient Houses," Health Physics, Vol. 45, pp. 401-405.

NLO Inc., 1985a, NLCO-2028 "Feed Materials Production Center Environmental Monitoring Annual Report for 1984," NLO Inc., Cincinnati, OH.

NLO Inc., 1985b, "Feed Materials Production Center Radioactive Waste Management Plan," NLCO-1100, Revision 6, NLO, Inc., Cincinnati, OH.

Nolan, R. J., F. A. Smith, and J. G. Hefner, 1979, "Elimination and Tissue Distribution of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) in Female Guinea Pigs Following a Single Oral Dose," Toxicology of Applied Pharmacology, Vol. 48, p. A162, (Cited in EPA 1985).

Norbach, D. H. and R. H. Weltman, 1985, "Polychlorinated Biphenyl Induction of Hepatocellular Carcinoma in the Sprague-Dawley Rat," Environmental Health Perspectives, Vol. 60, pp. 97-105, (Cited in EPA 1992a).

Nuttli, O. W., Seismicity of the Central United States Geological Society of America, Review in Engineering Geology, Vol. IV, 1979.

Ohio Environmental Protection Agency, 1989, "Great Miami River Intensive Stream Survey," OEPA, Southwest District Office, Dayton, OH.

Ohno, Y., T. Kawanishi, and A. Takahashi, 1986, "Comparisons of the Toxicokinetic Parameters in Rats Determined for Low and High Dose of Gamma-chlordane," Journal of Toxicological Science, Vol. 11, pp. 111-124, (Cited in ATSDR 1989_).

Olson, J. R., T. A. Gasiewicz, and R. A. Neal, 1980, "Tissue Distribution, Excretion, and Metabolism of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) in the Golden Syrian Hamster," Toxicology and Applied Pharmacology, Vol. 56, pp. 78-85, (Cited in EPA 1985).

Osanai, H., 1976, "An Experimental Study on Hepatoma Caused by Aromatic Amines," Rodo Kagaku, Vol. 52, pp. 179-201, (Cited in EPA 1992).

Pearson, E. S. and H. O. Hartley, 1966, Biometrika Tables for Statisticians, Vol. 1, 3rd ed., Cambridge University Press, London.

Piper, W. N., R. Q. Rose, and P. J. Gehring, 1973, "Excretion and Tissue Distribution of 2,3,7,8-Tetrachlorodibenzo-p-dioxin In the Rat," Environmental Health Perspectives, Vol. 5, pp. 241-244, (Cited in EPA 1985).

Poiger, H. and C. Schlatter, 1980, "Influence of Solvents and Adsorbents on Dermal and Intestinal Absorption of TCDD," Food and Cosmetic Toxicology, Vol. 18, pp. 477-481, (Cited in EPA 1985).

Poiger, H. and C. Schlatter, 1979, "Biological Degradation of TCDD in Rats," Nature, Vol. 281, pp. 706-707, (Cited in EPA 1985).

Polednak, A. P., 1978, "Bone Cancer Among Female Radium Dial Workers. Latency Periods and Incidence Rates by Time After Exposure," Journal of the National Cancer Institute, Vol. 60, pp. 77-82.

Polednak, A. P. and E. L. Frome, 1986, "Mortality Among Men Employed Between 1943 and 1947 at a Uranium Processing Plant," Journal of Occupational Medicine, Vol. 23, pp. 169-178.

Quast, J. F., J. W. Henck, D. J. Schuetz, D. A. Dittneber, and M. J. McKenna, 1982, "Allyl Chloride - Subchronic Studies, IB - Results of an Inhalation 4-day Probe and 90-day Subchronic Study in Laboratory Rodents," OTS Document #FYI-AX-O782-0199, (Cited in EPA 1992).

Rees, E. O., et al., 1971, "A Study of the Mechanism of Intestinal Absorption of Benzo(a)pyrene," Biochemical and Biophysical Act, Vol. 255, p. 96, (Cited in EPA 1980a).

Reeves, A. L., 1986a, "Barium," Handbook on the Toxicology of Metals, Friberg, L., G. F. Nordberg, and V. B. Vouk, eds., Vol. II, Elsevier Science Publishers B. V., New York, pp. 84-94.

Reeves, A. L., 1986b, "Beryllium," Handbook on the Toxicology of Metals, Friberg, L., G. F. Nordberg, and V. B. Vouk, eds., Vol. II, Elsevier Science Publishers B. V., New York, pp. 95-116.

Riedel, W., R. Hirschberg, A. Kaul, S. Schmier, and U. Walter, 1979, "Comparative Investigations on the Biokinetics of Colloidal Thorium, Zirconium, and Nafnium Dioxides in Animals," Environmental Research, Vol. 18, pp. 127-139.

Riedel, W., W. Dalheimer, A. Said, and U. Walter, 1983, "Recent Results of the Physical and Biological Properties of Thorotrast Equivalent Colloids," Health Physics, Vol. 44, Suppl. 1, pp. 293-298.

Rockstroh, H., 1959, "Zur Atiologie des Bronchialkrebses in Arsen Verarbeitenden Nickelhütten. Beitrag zur Syncarcinogenese des berufkrebes," Arch. Geschwulstforsch, Vol. 14, pp. 151-162.

Rose, J. Q., J. C. Ramsey, T. H. Wentzler, R. A. Hummel, and P. J. Gehring, 1976, "The Fate of 2,3,7,8-Tetrachlorodibenzo-p-dioxin Following Single and Repeated Oral Doses to the Rat," Toxicology and Applied Pharmacology, Vol. 36, pp. 209-226, (Cited in EPA 1985).

Rossi, L., M. Ravera, G. Repetti et al., 1977, "Long-term Administration of DDT or Phenobarbital in Wistar Rats," International Journal of Cancer, Vol. 19, pp. 179-185, (Cited in ATSDR 1989).

Rowland, R. E. and J. E. Farnham, 1969, "The Deposition of Uranium in Bone," Health Physics, Vol. 17, pp. 139-144.

Rowland, R. E., A. T. Keane, and P. M. Failla, 1971, "The Appearance Times of Radium-Induced Malignancies," Radiological Physics Division Annual Report, Report No. ANL-7860, Part II, Argonne National Laboratory, Argonne, IL, pp. 20-22.

Rowland, R. E., A. F. Stehney, and H. F. Lucas, Jr., 1978a, "Dose-Response Relationships for Female Radium Dial Workers," Radiation Research, Vol. 76, pp. 368-383.

Rowland, R. E., A. F. Stehney, A. M. Brues, M. S. Littman, A. T. Keane, B. C. Pattern, and M. M. Shanahan, 1978b, "Current Status of the Study of ^{226}Ra and ^{228}Ra in Humans at the Center for Human Radiobiology," Health Physics, Vol. 35, pp. 159-166.

Rowland, R. E., A. F. Stehney, and H. F. Lucas, 1983, "Dose-Response Relationships for Radium-Induced Bone Sarcomas," Health Physics, Vol. 44, Suppl. 1, pp. 15-31.

Rundo, J., A. T. Keane, H. F. Lucas, R. A. Schlenker, J. H. Stebbings, and A. F. Stehney, 1986, "Current (1984) Status of the Study of ^{226}Ra and ^{228}Ra in Humans at the Center for Human Radiobiology," Radiobiology of Radium and Thorotrast, W. Gossner, G. B. Gerber, U. Hagen, and A. Luz, eds., Urban and Schwarzenberg, Munich, West Germany, pp. 14-21.

Safe, S., 1980, "Metabolism, Uptake, Storage and Bioaccumulation of Halogenated Aromatic Pollutants In: R. D. Kimbrough, ed., Halogenated Biphenyls, Terphenyls, Naphthalenes, Dibenzodioxins and Related Products," Elsevier Science Publishers, Amsterdam, pp. 81-107, (Cited in ATSDR 1991).

Saffiotti, U., F. Cefis, R. Montesano, and A. R. Sellakumar, 1967, "Induction of Bladder Cancer in Hamsters Fed Aromatic Amines," Bladder Cancer, A Symposium, Aesculapius Publishing Co, Birmingham, AL, pp. 129-135, (Cited in EPA 1992).

Sandmeyer, E. E. and C. J. Kirwin, 1981, "Esters," Clayton, G. D. and F. E. Clayton, eds., Patty's Industrial Hygiene and Toxicology, Vol. II A, 3rd ed. revised, John Wiley and Sons, New York, pp. 2259-2412.

Saric, J. A., U.S. Environmental Protection Agency, March 11, 1992, [Letter to J. R. Craig, U.S. DOE, Subject: Draft Final Risk Assessment Work Plan Addendum].

Saric, J. A., U.S. Environmental Protection Agency, December 2, 1991, [Letter to J. R. Craig, U.S. DOE, Subject: Risk Assessment Work Plan Addendum].

Sax, N. I. and R. J. Lewis, Sr., eds., 1987, Hawley's Condensed Chemical Dictionary, 11th ed., Van Nostrand Reinhold Co., New York, pp. 63-64.

Sax, N. I., 1984, Dangerous Properties of Industrial Materials, 6th ed., Van Nostrand Reinhold Co., New York.

Scala, R. A., 1991, "Risk Assessment," M. O. Amdur, J. Doull, and C. D. Klaassen, eds., Casarett and Doull's Toxicology, the Basic Science of Poisons, 4th ed., Pergamon Press, New York, pp. 985-996.

Schaeffer, E., H. Grein, and W. Goessner, 1984, "Pathology of Chronic Polychlorinated Biphenyl (PCB) Feeding in Rats," Toxicology and Applied Pharmacology, Vol. 75, pp. 278-288, (Cited in EPA 1992a).

Schlede, E. et al., 1970a, "Effect of Enzyme Induction on the Metabolism and Tissue Distribution of Benzo(a)pyrene," Cancer Research, Vol. 30, p. 2893, (Cited in EPA 1980a).

Schlede, E., et al., 1970b, "Stimulatory Effect of Benzo(a)pyrene and Phenobarbital Pretreatment on the Biliary Excretion of Benzo(a)pyrene Metabolites in the Rat," Cancer Research, Vol. 30, p. 2898, (Cited in EPA 1980a).

Schlenker, R. A., 1980, "Dosimetry of Paranasal Sinus and Mastoid Epithelia in Radium-Exposed Humans," Radiological and Environmental Research Division Annual Report, No. ANL-80-115, Part II, Argonne National Laboratory, Argonne, IL, pp. 1-21.

Schmahl, D., 1955, "Examination of the Carcinogenic Action of Naphthalene and Anthracene in Rats, Z. Krebsforsch, Vol. 60, pp. 697-710, (Cited in EPA 1992a).

Schnellmann, R. G., C. W. Putnam, and I. G. Sipes, 1983, "Metabolism of 2,2',3,3',6,6'-Hexachlorobiphenyl and 2,2',4,4',5,5'-Hexachlorobiphenyl by Human Hepatic Microsomes," Biochemistry and Pharmacology, Vol. 32, pp. 3233-3239, (Cited in ATSDR 1991).

Schnellmann, R. G., R. F. Volp, C. W. Putnam et al., 1984, "The Hydroxylation, Dechlorination, and Glucuronidation of 4,4'-Dichlorobiphenyl (4-DCB) by Human Hepatic Microsomes," Biochemistry and Pharmacology, Vol. 33, pp. 3503-3509, (Cited in ATSDR 1991).

Schroeder, H. A., A. P. Nason, and I. H. Tipton, 1967, "Essential Trace Elements in Man: Cobalt, Journal of Chronic Diseases, Vol. 20, pp. 869-890, (Cited in EPA 1992_).

Schroeder, H. A., M. Mitchner, and A. P. Nasor, 1970, "Zirconium, Niobium, Antimony, Vanadium and Lead in Rats: Life Term Studies," Journal of Nutrition, Vol. 100, pp. 59-66, (Cited in EPA 1992_).

Schwartz, P. M., S. W. Jacobson, G. Fein et al., 1983, "Lake Michigan Fish Consumption as a Source of Polychlorinated Biphenyls in Human Cord Serum, Maternal Serum, and Milk," American J. of Public Health, Vol. 73, pp. 293-296, (Cited in ATSDR 1991).

Shacklette, H. T. and J. G. Boerngen, 1984, Elemental Concentrations in Soils and Other Surficial Materials of the Conterminous United States, U.S. Geological Survey Professional Paper 1270, U.S. Dept. of the Interior, Washington, DC.

Sherman, H., 1974, "Long-term Feeding Studies in Rats and Dogs with Dichlorodifluoromethane (Freon 12 Food Freezant)," Medical Research Project No. 1388, Haskell Laboratory Report No. 24-74, Unpublished, Courtesy of du Pont de Nemours Co., (Cited in EPA 1992).

Singh, A. R., W. H. Lawrence and J. Autian, 1972, "Teratogenicity of Phthalate Esters in Rats, Journal of Pharmacological Science, Vol. 61, pp. 51-55, (Cited in EPA 1992_).

Sinks, T., A. B. Smith, R. Rinsky et al., 1991, "Health Hazard Evaluation Report," Westinghouse Electric Corporation, Bloomington, IN, Cincinnati, OH: Hazard Evaluations and Technical Assistance Branch, NIOSH, HETA 89-116-2094, (Cited in ATSDR 1991).

Smith, R. P., 1991, "Toxic Responses of the Blood," Casarett and Doull's Toxicology, the Basic Science of Poisons, M. O. Amdur, J. Doull, and C. D. Klaassen, eds., 4th ed., Pergamon Press, New York, pp. 257-281.

Southwick, J. W., A. E. Western, M. M. Beck et al., 1983, "An Epidemiological Study of Arsenic in Drinking Water in Millard County, Utah," Lederer, W. H. and R. J. Fensterheim, eds., Arsenic: Industrial, Biomedical, Environmental Perspectives, Van Nostrand Reinhold Co., New York, pp. 210-225, (Cited in EPA 1992).

Spiers, F. W., H. F. Lucas, J. Rundo, and G. A. Anast, 1983, "Leukemia Incidence in the U.S. Dial Workers," Health Physics, Vol. 44, Suppl. 1, pp. 65-72.

Spiess, H., 1969, "²²⁴Ra-Induced Tumors in Children and Adults," Delayed Effects of Bone-seeking Radionuclides, C. W. Mays, W. S. S. Jee, R. D. Lloyd, B. J. Stover, J. H. Dougherty, and G. N. Taylor, eds., University of Utah Press, Salt Lake City, UT, pp. 227-247.

Spiess, H. and C. W. Mays, 1970, "Bone Cancers Induced by Ra-224 (ThX) in Children and Adults," Health Physics, Vol. 19, pp. 713-729.

Sprince, N. L., L. C. Oliver, E. A. Eisen et al., 1988, "Cobalt Exposure and Lung Disease in Tungsten Carbide Production: A Cross-sectional Study of Current Workers," American Review of Respiratory Diseases, Vol. 138, pp. 1220-1226, (Cited in EPA 1990).

Stebbing, J. H., H. F. Lucas, and A. F. Stehney, 1984, "Mortality from Cancers of Major Sites in Female Radium Dial Workers," American Journal of Industrial Medicine, Vol. 5, pp. 435-459.

Stevens, W., F. W. Bruenger, D. R. Atherton, J. M. Smith, and G. N. Taylor, 1980, "The Distribution and Retention of Hexavalent ²³³U in the Beagle," Radiation Research, Vol. 83, pp. 109-126.

Stokinger, H. E., 1982, "Uranium," Patty's Industrial Hygiene and Toxicology, 3rd ed.

Storey, E., 1961, "Strontium 'Rickets' Bone Calcium and Strontium Changes," Astral. Ann. Med., Vol. 10, pp. 213-222.

Stula, E. F., H. Sherman, J. A. Zapp, and J. W. Clayton, 1975, "Experimental Neoplasia in Rats from Oral Administration of 3,3'-Dichlorobenzidine, 4,4'-Methylene-bis(2-chloroaniline), and 4,4'-Methylene-bis(2-methylaniline)," Toxicology and Applied Pharmacology, Vol. 31, pp. 159-176, (Cited in EPA 1992).

Stula, E. F., J. R. Barnes, H. Sherman, C. F. Reinhardt, and J. A. Zapp, 1978, "Liver and Urinary Bladder Tumors in Dogs from 3,3'-Dichlorobenzidine," Journal of Environmental Pathology and Toxicology, Vol. 1, pp. 475-490, (Cited in EPA 1992).

Tanabe, S., Y. Nakagawa, and R. Tatsukawa, 1981, "Absorption Efficiency and Biological Half-life of Individual Chlorobiphenyls in Rats Treated with Kanechlor Products," Agricultural and Biological Chemistry, Vol. 45, pp. 717-726, (Cited in ATSDR 1991).

Teitelbaum, P. J. and A. P. Poland, 1978, "Studies of the Hepatic Uptake of 2,3,7,8-Tetrachlorodibenzo-p-dioxin in the Mouse," Proceedures of the American Society for Experimental Biology, Vol. 37, p. 692, (Cited in EPA 1985).

Theiss, J. C., G. D. Stoner, M. B. Shimkin, and E. K. Weisburger, 1977, "Test for Carcinogenicity of Organic Contaminants of United States Drinking Waters by Pulmonary Tumor Response in Strain A Mice," Cancer Research, Vol. 37, pp. 2717-2720, (Cited in EPA 1984).

Theiss, J. C., M. B. Shimkin, and L. A. Poirer, 1979, "Induction of Pulmonary Adenomas in Strain A Mice by Substituted Organohalides," Cancer Research, Vol. 39, pp. 391-395, (Cited in EPA 1992).

Thorslund, T. and G. Charnley, 1988, "Comparative Potency Approach for Estimating the Cancer Risk Associated with Exposure to Mixtures of Polycyclic Aromatic Hydrocarbons," ICF-Clement Associates, Washington, DC, (Cited in Krewski et al. 1989; cited as Clement Associates 1988 in EPA 1991).

0726

Thun, M. J., T. M. Schnorr, A. B. Smith, and W. E. Halperin, 1985, "Mortality Among a Cohort of U.S. Cadmium Production Workers: An Update," Journal of the National Cancer Institute, Vol. 74, pp. 325-333, (Cited in EPA 1992).

Tipton, I. H., P. L. Stewart, and P. G. Martin, 1966, "Trace Elements in Diets and Excreta," Health Physics, Vol. 12, pp. 1683-1689, (Cited in EPA 1992).

Torkelson, T. R., M. A. Wolf, F. Oyen, and V. K. Rowe, 1959, "Vapor Toxicity of Allyl Chloride as Determined on Laboratory Animals," American Industrial Hygiene Association J. Vol. 20, pp. 217-223, (Cited in EPA 1992).

Treon, J. F., F. P. Cleveland, J. W. Cappel et al., 1956, "The Toxicity of the Vapours of Aroclor-1242 and Aroclor-1254," American Industrial Hygiene Association Journal, Vol. Q, No. 17, pp. 204-213, (Cited in ATSDR 1991).

Tseng, W. P., H. M. Chu, S. W. How, J. M. Fong, C. S. Lin, and S. Yeh, 1968, "Prevalence of Skin Cancer in an Endemic Area of Chronic Arsenicism in Taiwan," Journal of the National Cancer Institute Vol. 40, pp. 453-463, (Cited in EPA 1992).

Tseng, W. P., 1977, "Effects and Dose-response Relationships of Skin Cancer and Blackfoot Disease with Arsenic," Environmental Health Perspectives, Vol. 19, pp. 109-119, (Cited in EPA 1992).

Tsuchiya, K., 1986, "Lead," Handbook on the Toxicology of Metals, Friberg, L., G. F. Nordberg, and V. B. Vouk, eds., Vol. II, 2nd ed., Elsevier Science Publishers B. V., New York, pp. 298-353.

Underwood, E. J., 1977, Trace Elements in Human and Animal Nutrition, 4th ed., Academic Press, New York.

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 1982, "Ionizing Radiation: Sources and Biological Effects," Report to the General Assembly, with Annexes, United Nations Scientific Committee on the Effects of Atomic Radiation, New York, NY.

U.S. Dept. of Agriculture, Soil Conservation Service, Ohio Dept. of Natural Resources, Division of Lands and Soil, and Ohio Agricultural Research and Development Center, 1980, "Soil Survey of Butler County, Ohio," USDA, ODNR, and Ohio Agricultural Research and Development Center.

U.S. Dept. of Agriculture, Soil Conservation Service, 1982, "Soil Survey of Hamilton County, Ohio," USDA, SCS, Washington, DC.

U.S. Dept. of Energy, 1989, "Environmental Impact Statement, FMPC Renovation and Site Evaluation," completed May 18, 1989, Draft 4, Green Cover Review.

U.S. Dept. of Energy, 1992a, "Risk Assessment Work Plan Addendum," prepared for Remedial Investigation and Feasibility Study, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Field Office, Fernald, OH.

U.S. Dept. of Energy, 1992b, "RCRA/CERCLA Background Soil Study, Sampling and Analysis Plan," Final, prepared for Remedial Investigation/Feasibility Study, Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Field Office, Fernald, OH.

U.S. Dept. of Energy, 1992c, "Remedial Investigation Report for Operable Unit 2," Prepared for the Fernald Environmental Management Project, U.S. Dept. of Energy, Fernald Field Office, Fernald, OH.

U.S. Dept. of Energy, 1992d, "Operable Unit 3 Work Plan Addendum, Fernald Environmental Management Project, Fernald, OH, Remedial Investigation and Feasibility Study," U.S. Dept. of Energy, Fernald Office, Fernald, OH.

U.S. Dept. of Energy, 1993a, "Characterization of Background Water Quality for Streams and Groundwater," Fernald Environmental Management Project, May 1993, Draft.

U.S. Dept. of Energy, 1993b, "CERCLA/RCRA Background Soil Study," Fernald Environmental Management Project, RI/FS, March 1993 Final.

U.S. Dept. of Energy, 1993c, "Site-Wide Characterization Report," Fernald Environmental Management Project, March 1993, Final.

U.S. Dept. of Health and Human Services, "Toxicological Profile for Plutonium," Agency for Toxic Substances, TP-90-21, December 1990b.

U.S. Environmental Protection Agency (EPA), 1979a, Multimedia Health Assessment Document for Polycyclic Organic Matter, Prepared under contract by J. Santodonato et al., Syracuse Research Corporation, (Cited in EPA 1980a).

U.S. Environmental Protection Agency (EPA), 1979b, Polynuclear Aromatic Hydrocarbons: Ambient Water Quality Criteria (Draft), (Cited in EPA 1980a).

U.S. Environmental Protection Agency (EPA), 1979c, Naphthalene: Ambient Water Quality Criteria, (Draft), (Cited in EPA 1980a).

U.S. Environmental Protection Agency (EPA), 1980a, Ambient Water Quality Criteria for Polynuclear Aromatic Hydrocarbons, Office of Water Regulations and Standards, Washington, DC, EPA 440/5-80-069, NTIS PB81-117806, (Cited in ATSDR 1987).

U.S. Environmental Protection Agency (EPA), 1980b, Identification and Listing of Hazardous Waste Under RCRA, Subtitle C, Section 3001, Health and Environmental Effects Profiles, Office of Solid Waste, Washington, DC, NTIS No. PB81 190019.

U.S. Environmental Protection Agency (EPA), 1984, Health and Environmental Effects Profile for Brominated Diphenyl Ethers, Prepared by Environmental Criteria and Assessment Office, Cincinnati, OH for Office of Solid Waste, Washington, DC, EPA-600/X-84-133, NTIS PB88 131529.

U.S. Environmental Protection Agency (EPA), 1985, Health Assessment Document for Polychlorinated Dibenzo-p-Dioxins, Office of Health and Environmental Assessment, Washington, DC, EPA/600/8-84/014F, NTIS No. PB86-122546.

U.S. Environmental Protection Agency (EPA), 1986a, o, m, p-Cresol, 90-Day oral subchronic toxicity studies in rats, Office of Solid Waste, Washington, DC, (Cited in EPA 1992).

U.S. Environmental Protection Agency (EPA), 1986b, "Guidelines for Carcinogen Risk Assessment," Federal Register 51 (185), pp. 33992-34003.

U.S. Environmental Protection Agency (EPA), 1987a, Health Effects Assessment for Antimony and Compounds, Prepared by Office of Health and Environmental Assessment, Cincinnati, OH, for the Office of Solid Waste and Emergency Response, Washington, DC, EPA/600/8-88/018, NTIS PB 88-179445.

U.S. Environmental Protection Agency (EPA), 1987b, o, m, p-Cresol, 90-Day oral subchronic neurotoxicity study in rats, Office of Solid Waste, Washington, DC, (Cited in EPA 1992).

U.S. Environmental Protection Agency (EPA), 1988a, "Laboratory Data Validation - Functional Guidelines For Evaluating Organic Analyses," EPA, Hazardous Site Evaluation Division, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1988b, "Laboratory Data Validation - Functional Guidelines For Evaluating Inorganic Analyses," EPA, Hazardous Site Evaluation Division, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1988c, 13-Week mouse oral subchronic toxicity study, Prepared by Toxicity Research Laboratories, Ltd., Muskegon, MI for Office of Solid Waste, Washington, DC, (Cited in EPA 1992a).

U.S. Environmental Protection Agency (EPA), 1988d, Health Effects Assessment for Trichloroethylene, Prepared by the Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste and Emergency Response, Washington, DC, EPA/600/8-89/097, NTIS No. PB90-142498.

U.S. Environmental Protection Agency (EPA), Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, EPA/520/1-88/020.

U.S. Environmental Protection Agency (EPA), 1989a, "Risk Assessment Guidance for Superfund: Human Health Manual, Part A, Interim Final," EPA/540/1-89/002, EPA, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1989b, "Exposure Factors Handbook," EPA/600/8-89/043, EPA, Office of Health and Environmental Assessment, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1989c, "Methods for Evaluating the Attainment of Cleanup Standards, Vol. 1: Soils and Solid Media," EPA/230/02-89-042, Office of Policy, Planning, and Evaluation, Washington, DC.,

U.S. Environmental Protection Agency (EPA), 1989d, "Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance," EPA/530-SW-89-026, EPA, Office of Solid Waste, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1989e, Mouse oral subchronic study with acenaphthene, Study conducted by Hazelton Laboratories, Inc., for the Office of Solid Waste, Washington, DC, (Cited in EPA 1992a).

U.S. Environmental Protection Agency (EPA), 1989f, Subchronic toxicity in mice with anthracene, Final Report, Hazelton Laboratories America, Inc, prepared for Office of Solid Waste, Washington, DC, (Cited in EPA 1992a).

U.S. Environmental Protection Agency (EPA), 1989g, Mouse oral subchronic toxicity study, prepared by Toxicity Research Laboratories, Ltd., Muskegon, MI for Office of Solid Waste, Washington, DC, (Cited in EPA 1992a).

U.S. Environmental Protection Agency (EPA), 1989h, Mouse oral subchronic toxicity of pyrene, Study conducted by Toxicity Research Laboratories, Muskegon, MI for the Office of Solid Waste, Washington, DC, (Cited in EPA 1992a).

U.S. Environmental Protection Agency (EPA), 1989i, "General Quantitative Risk Assessment Guidelines for Noncancer Health Effects," prepared by the Office of Health and Environmental Assessment for the Risk Assessment Forum, ECAO-CIN-538, Cincinnati, OH.

U.S. Environmental Protection Agency (EPA), 1989j, "Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-Dioxins and Dibenzofurans (CDDs and CDFs) and 1989 Update," PB90-145756.

U.S. Environmental Protection Agency (EPA), 1989k, "Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites, OSWER Directive No. 9355.4-02, September 1989.

U.S. Environmental Protection Agency (EPA), 1990a, "Statistical Methods for Evaluating the Attainment of Cleanup Standards, Vol. 1 and Vol. 3: Background-Based Standards for Soils and Solid Media," prepared for the EPA under a Related Services Agreement with the U.S. Dept. of Energy, Contract DE-AC06-76RLO 1830, by Pacific Northwest Laboratory, Richland, WA.

U.S. Environmental Protection Agency (EPA), 1990b, Memorandum from Pei-Fung Hurst, ECAO, Cincinnati, OH to R. Riccio, EPA Region III, Philadelphia, PA, Subject: Toxicity of Cobalt (Halby Chemical/Wilmington, Delaware), dated October 9, 1990.

U.S. Environmental Protection Agency (EPA), 1990c, Technical Support Document for Lead, Prepared by the Chemical Hazard Assessment Division, Syracuse Research Corporation, under contract to the Environmental Criteria and Assessment Office, Cincinnati, OH.

U.S. Environmental Protection Agency (EPA), 1991a, "Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Vol. I, Supplemental Guidance, Standard Default Exposure Factors, Interim Final," EPA, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1991b, "Health Effects Assessment Summary Tables, FY - 1991," OERR 9200.6-303(91-1), EPA, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1991c, "User's Guide for Lead: A PC Software Application of the Uptake/Biokinetic Model Version 0.50," prepared by Syracuse Research Corporation Under Contract No. 68-CO-0043 for the Environmental Criteria and Assessment Office, Cincinnati, OH.

U.S. Environmental Protection Agency (EPA), 1991d, "User's Guide for CAP 88-PC, Version 1.0," EPA 520/6-91/022, EPA, Office of Radiation programs, Las Vegas, NV.

U.S. Environmental Protection Agency (EPA), 1991e, "Drinking Water Criteria Document for Polycyclic Aromatic Hydrocarbons (PAHs), prepared by the Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Water, Washington DC, ECAO-CIN-D010, NTIS PB92-173459.

U.S. Environmental Protection Agency (EPA), 1991f, "Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual, Part B, Development of Risk-Based Preliminary Remediation Goals." Publication 9285.7-01B. EPA, Office of Emergency and Remedial Response.

0730

U.S. Environmental Protection Agency (EPA), 1991g, "Laboratory Data Validation - Functional Guidelines for Evaluating Organic Analyses," Hazardous Site Evaluation Division, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1991h, "Laboratory Data Validation - Functional Guidelines for Evaluating Inorganic Analyses," Hazardous Site Evaluation Division, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1991i, "Update on OSWER Soil Lead Cleanup Guidance, Memorandum from D. R. Clay, Office of Solid Waste and Emergency Response, August 1991.

U.S. Environmental Protection Agency (EPA), 1992, "Risk Assessment Guidance for Superfund, Vol. I, HHEM, Supplemental Guidance for Superfund, Dermal Risk Assessment, Interim Guidance, Public 9285.7-01B. EPA, OERR.

U.S. Environmental Protection Agency (EPA), 1992b, "Health Effects Assessment Summary Tables, Annual Update FY 1992," including Suppl. A, July 1992, prepared by the Environmental Criteria and Assessment Office, Cincinnati, OH, for the Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1992c, "Supplemental Guidance to RAGS: Calculating the Concentration Term," prepared by the Office of Solid Waste and Emergency Response, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1992d, "Guidance on Risk Characterization for Risk Assessors and Risk Managers," memorandum dated February 26, 1992.

U.S. Environmental Protection Agency (EPA), 1992e, "Dermal Exposure Assessment: Principles and Applications," EPA/600/8-91/011B, prepared by the Office of Research and Development, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1992f, "Drinking Water Regulations and Health Advisories," Office of Water, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1992g, Memorandum from D. L. Forman, U.S. EPA Region III, Philadelphia, PA, Subject: Cobalt Toxicity, dated March 12, 1992.

U.S. Environmental Protection Agency (EPA), 1992h, Risk Assessment Teleconference for Superfund (RATS), May 13, 1992 meeting notes, Superfund Technical Support Center, Environmental Criteria and Assessment Office, Cincinnati, OH.

U.S. Environmental Protection Agency (EPA) 1992i, "Risk Assessment Guidance for Superfund, Vol. I: Human Health Evaluation Manual. Supplemental Guidance for Superfund, Dermal Risk Assessment, Interim Guidance." Publication 9285.7-01B. EPA, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1993a, "Integrated Risk Information System (IRIS)" computer database, EPA, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1993b, "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening," Region III Technical Guidance Manual.

U.S. Environmental Protection Agency (EPA), 1993c, Memorandum from Roy L. Smith, Region III Technical Support System, to RBC Table mailing list, Subject: Risk-Based Concentration Table, Second Quarter 1993; dated May 10, 1993.

U.S. Environmental Protection Agency (EPA), 1993d, Memorandum from J. Dollaride, ECAO, to P. VanLeeuwen, EPA Region V, July 21, 1993. Attachment G: "Review of Position Paper on Proposed Modifications to Soil Cleanup Levels."

U.S. Environmental Protection Agency (EPA), 1993e, "Drinking Water Regulations and Health Advisories," May 1993, Office of Water, Washington, DC.

U.S. Environmental Protection Agency (EPA), 1993f, "Provisional Guidance for Qualitative Risk Assessment of Polycyclic Aromatic Hydrocarbons," March 1993, ECAO-CIN-842.

U.S. Nuclear Regulatory Commission (NRC), 1977, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR Part 50, Appendix I: Regulatory Guide 1.109, NRC, Office of Standards Development, Washington, DC.

U.S. Nuclear Regulatory Commission, 1983, "Radiological Assessment: A Textbook on Environmental Dose Analysis," NUREG/CR-3322, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, DC.

U.S. Nuclear Regulatory Commission, 1984, "De Minimis Waste Impacts Analysis Methodology," prepared for Division of Waste Management, NRC FIN B7318, U.S. NRC, Washington, DC.

Uzhdavini, E. R., I. K. Astaf'yeva, A. A. Mamayeva, and G. Z. Bakhtizina, 1972, "Inhalation Toxicity of o-Cresol," Tr. Ufimskogo Nauchno-Issledovatel'skogo Instituta Gigiyeny Profzabolevaniya, Vol. 7, pp. 115-119, (English translation) (Cited in EPA 1992).

Vainich, et al., 1976, "The Fate of Intratracheally Instilled Benzo(a)pyrene in the Isolated Perfused Rat Lung of Both Control and 20-Methylcholanthrene Pretreated," Research Communications in Chemical Pathology and Pharmacology, Vol. 13, pp. 259, (Cited in EPA 1980).

Van Bruwaene, R. Hegela, M. Gerber, G. B. Kirchmann, and R. Maisin, 1986, "Toxicity of Long-term Application of Dietary Technitium to Rats and the Offspring Bound to Food," Desmet, G. Myttenaere, C. eds., Technitium in the Environment, Elsevier App. Science Publ., London, New York, pp. 385-398.

Van Duuren, B. L., B. M. Goldschmidt, G. Loewengart, A. C. Smith, S. Melchionne, I. Seldman, and D. Roth, 1979, "Carcinogenicity of Halogenated Olefinic and Aliphatic Hydrocarbons in Mice," Journal of the National Cancer Institute, Vol. 63, pp. 1433-1439, (Cited in EPA 1992).

van Kaick, G., A. Kaul, D. Lorenz, H. Muth, K. Wegener, and H. Wesch, 1978a, "Late Effects and Tissue Dose in Thorotrast Patients. Recent Results of the German Thorotrast Study," Late Biological Effects of Ionizing Radiation, International Atomic Energy Agency, Vienna, Austria, Vol. 1, pp. 263-276.

van Kaick, G., D. Lorenz, H. Muth, and A. Kaul, 1978b, "Malignancies in German Thorotrast Patients and Estimated Tissue Dose," Health Physics, Vol. 35, pp. 127-136.

4787
van Kaick, G., H. Muth, and A. Kaul, H. Immich, D. Liebermann, D. Lorenz, W. J. Lorenz, H. Luhrs, K. E. Scheer, G. Wagner, K. Wegener, and H. Wesch, 1983, "Recent Results of German Thorotrast Study - Epidemiological Results and Dose Effect Relationships in Thorotrast Patients," Health Physics, Vol. 44, Supp. 1, pp. 299-306.

van Kaick, G., H. Muth, A. Kaul, H. Immich, D. Liebermann, D. Lorenz, W. J. Lorenz, W. J. Luhrs, K. E. Scheer, G. Wagner, K. Wegener, and H. Wesch, 1984a, "Results of the German Thorotrast Study," Radiation Carcinogenesis, Epidemiology and Biological Significance, J. D. Boice, Jr. and J. F. Fraumeni, Jr., eds., Raven, NY.

van Kaick, G., H. Muth, and A. Kaul, 1984b, "The German Thorotrast Study," Results of Epidemiological, Clinical and Biophysical Examinations on Radiation-Induced Late Effects in Man Caused by Incorporated Colloidal Thorium Dioxide (Thorotrast), Report No. EUR 9504 EN, Commission of the European Communities, Luxembourg, Germany.

van Kaick, G., H. Muth, A. Kaul, H. Wesch, H. Immich, D. Liebermann, W. J. Lorenz, H. Luhrs, K. E. Scheer, G. Wagner, and K. Wegener, 1986, "Report on the German Thorotrast Study," Strahlentherapie, Vol. 80, pp. 114-118.

Van Miller, J. P., R. J. Marlar, and J. R. Allen, 1976, "Tissue Distribution and Excretion of Tritiated Tetrachlorodibenzo-p-dioxin in Non-human Primates and Rats," Food and Cosmetic Toxicology, Vol. 14, pp. 31-34, (Cited in EPA 1985).

Velsicol Chemical Co., 1983, "Thirty-month Chronic Toxicity and Tumorigenicity Test in Rats by Chlordane Technical," Unpublished study by Research Institute for Animal Science in Biochemistry and Toxicology (RIASBT), Japan, (Cited in ATSDR 1989; EPA 1992).

Wagoner, J. K., V. E. Archer, B. E. Carroll, and D. A. Holaday, 1964, "Cancer Mortality Patterns Amongst U.S. Uranium Miners and Millers, 1950 Through 1962," Journal of the National Cancer Institute, Vol. 32, pp. 787-801.

Watkins, J. S. and A. M. Speiker, 1971 "Seismic Refraction Survey of Pleistocene Drainage Channels in the Lower Great Miami River Valley, Ohio," USGS Professional Paper 605-B.

Waxweiler, R. J., V. E. Archer, R. J. Roscoe, A. Watanabe, and J. J. Thun, 1983, "Mortality Patterns Among a Retrospective Cohort of Uranium Mill Workers," Proceedings of the Health Physics Society, presented at Epidemiology Applied to Health Physics, pp. 428-435.

Wesch, H., H. Kampmann, and K. Wegener, 1973, "Assessment of Organ Distribution of Thorium by Neutron-Activation-Analysis," Proceedings of the Third International Meeting on the Toxicity of Thorotrast, Riso Report 294, M. Faber, ed., Danish Atomic Energy Commission, Copenhagen, Denmark, pp. 52-60.

Wesch, H., W. Riedel, K. Wegener, A. Kaul, H. Immich, K. Hasenohrl, H. Muth, and G. van Kaick, 1983, "Recent Results of the German Thorotrast Study - Statistical Evaluation of Animal Experiments With Regard to the Nonradiation Effect in Human Thorotrastosis," Health Physics, Vol. 44, Suppl. 1, pp. 317-321.

Wesch, H., U. W. Riedel, K. Hasenohrl, K. Wegener, A. Kaul, H. Muth, and G. van Kaick, 1986, "German Thorotrast Study: Results of the Long-Term Animal Studies on the Effect of Incorporated Radioactive and Nonradioactive Particles," Strahlentherapie, Vol. 80, pp. 186-188.

Wester, R. C., H. I. Maibach, D. A. Bucks et al., 1990, Percutaneous absorption and skin decontamination of PCBs: In vitro studies with human skin and in vivo studies in the rhesus monkey, Journal of Toxicology and Environmental Health, Vol. 12, pp. 511-519, (Cited in ATSDR 1991).

Wester, R. C., D. A. W. Bucks, H. I. Maibach et al., 1983, "Polychlorinated Biphenyls (PCBs): Dermal Absorption, Systemic Elimination, and Dermal Wash Efficiency," Journal of Toxicology and Environmental Health, Vol. 12, pp. 511-519, (Cited in ATSDR 1991).

Westinghouse Environmental Management Company of Ohio (WEMCO), 1987, "Feed Materials Production Center Environmental Monitoring Annual Report for 1986," FMPC-2076, WEMCO, Cincinnati, OH, prepared for U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

Williams, G. M. and J. H. Weisburger, 1991, "Chemical Carcinogenesis," M. O. Amdur, J. Doull, and C.D. Klaassen, eds., Casarett and Doull's Toxicology, the Basic Science of Poisons, 4th ed., Pergamon Press, New York, pp. 127-200.

Wolff, M. S., 1985, "Occupational Exposure to Polychlorinated Biphenyls (PCBs)," Environmental Health Perspectives, Vol. 60, pp. 133-138, (Cited in ATSDR 1991).

Wolff, M. S., J. Thornton, A. Fischbein et al., 1982, "Disposition of Polychlorinated Biphenyl Congeners in Occupationally Exposed Persons," Toxicology and Applied Pharmacology, Vol. 62, pp. 294-306, (Cited in ATSDR 1991).

Wrenn, M. E., P. W. Durbin, D. L. Willis, and N. P. Singh, 1987, "The Potential Toxicity of U in Water," Journal of the American Water Works Association, Vol. 79, pp. 177-184.

Yuile, C. L., 1973, "Animal Experiments (Chapter 3)," Uranium, Plutonium and the Transuranic Elements, Hodge, Stannard, and Hursh, eds.

LIST OF TABLES

4787

	<u>Page</u>
E.I-1 Background Concentrations of Radon in Air	E.I-1
E.I-2 Summary Statistics for Background Concentrations of Radionuclides and Inorganic Chemicals in Great Miami River Water	E.I-2
E.I-3 Background Concentrations of Radionuclides and Inorganic Chemicals in the Great Miami Aquifer	E.I-4
E.I-4 Summary Statistics for Background Concentrations of Inorganic Chemicals in Soil	E.I-7
E.I-5 Summary Statistics for Background Concentrations of Radiological Constituents	E.I-16

LIST OF FIGURES

E.I-1 Surface Water Background Sampling Location for Operable Unit 1	E.I-17
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0735

TABLE EJ-1

BACKGROUND CONCENTRATIONS OF RADON IN AIR

Radionuclide	Date	Frequency of Detection	Range of Detection (pCi/L)	Distribution	Arithmetic Mean (pCi/L)	Upper 95% UCL on Arithmetic Mean (pCi/L)
Rn-222	10/91	741/741	0.100 - 2.700	Lognormal	0.866	0.899
Rn-222	12/91	741/741	0.200 - 2.400	Lognormal	0.611	0.630

EJ-2

0736

4282

TABLE E.I-2

SUMMARY STATISTICS FOR BACKGROUND CONCENTRATIONS OF RADIONUCLIDES
AND INORGANIC CHEMICALS IN GREAT MIAMI RIVER WATER

Constituent	Total Analysis	Total Detection	Detection Frequency (%)	Minimum Detection	Maximum Detection	Maximum SQL	Median
Radionuclides (pCi/g)^a							
Np-237	5	0	0	-	-	1	<1
Pu-238	5	0	0	-	-	1	<1
Pu-239/240	5	0	0	-	-	1	<1
Ra-226	5	0	0	-	-	1	<1
Ra-228	5	0	0	-	-	3	<3
Sr-90	4	0	0	-	-	5	<5
Tc-99	5	0	0	-	-	30	<30
Th-228	5	0	0	-	-	1	<1
Th-230	5	0	0	-	-	1	<1
Th-232	5	0	0	-	-	1	<1
U-234	5	1	20	-	1.1	1	<1
U-235/236	5	0	0	-	-	1	<1
U-238	5	0	0	-	-	1	<1
Chemical (µg/L)							
Ammonia	3	3	100	0.1	1.2	NA	0.11
Arsenic	2	0	0	NA	NA	0.002	<0.002
Barium	3	3	100	0.0493	0.100	NA	0.089
Cadmium	4	1	25	0.006	0.0098	0.005	0.006
Calcium	4	3	75	61.2	77	NA	70.5
Chloride	3	3	100	17.99	325	NA	135
Chromium	4	0	0	NA	NA	0.02	<0.002
Copper	4	0	0	NA	NA	0.01	<0.01
Fluoride	3	3	100	0.31	0.9	NA	0.82
Iron	4	2	50	0.164	0.22	0.005	0.095
Lead	3	0	0	NA	NA	0.01	0.005
Magnesium	4	4	100	21.5	34.9	NA	31.05
Manganese	4	2	50	0.08	0.0089	0.02	0.045
Mercury	4	1	25	NA	0.0095	0.0002	<0.0002
Molybdenum	4	1	25	NA	0.02	0.02	<0.02

TABLE EJ-2
(Continued)

4787

Constituent	Total Analysis	Total Detection	Detection Frequency (%)	Minimum Detection	Maximum Detection	Maximum SQL	Median
Nickel	4	1	25	NA	0.0105	0.02	<0.02
Nitrate	3	3	100	0.4	6.58	NA	3.2
Phosphorus	3	3	100	0.299	1.1	NA	0.59
Potassium	3	3	100	2.3	6.2	NA	4.03
Selenium	2	0	0	NA	NA	0.002	<0.002
Silver	5	0	0	NA	NA	0.1	<0.03
Sodium	4	4	100	12.9	77.2	NA	72.9
Sulfate	3	3	100	114.9	4310	NA	138
Uranium-Total ^b	5	3	60	1	1	1	1

^aSamples were not analyzed for Cs-137, Ru-106, Th-total, and U-235.

^bAdditional statistics for U-total: arithmetic mean is 0.8, arithmetic standard deviation is 0.3, geometric mean is 0.8, and geometric standard deviation is 1.5

TABLE E.I-3

**BACKGROUND CONCENTRATIONS OF RADIONUCLIDES AND INORGANIC
CHEMICALS IN THE GREAT MIAMI AQUIFER**

Constituent	Total Analyses	Total Detections	Detection Frequency	Minimum Detection	Maximum Detection	Median	Arithmetic Mean	95% UCL on Arithmetic Mean
Radionuclides (pCi/L)								
Cs-137	5	0	0	-	-	<20	NA	NA
Np-237	103	0	0	-	-	<1	NA	NA
Pu-238	105	0	0	-	-	<1	NA	NA
Pu-239/240	105	0	0	-	-	<1	NA	NA
Ra-226	95	6	6	1.1	8.5	<1	NA	NA
Ra-228	91	8	9	3.1	5.5	<3	NA	NA
Ru-106	6	0	0	-	-	<150	NA	NA
Sr-90	107	0	0	-	-	<5	NA	NA
Tc-99	114	1	1	-	36	<30	NA	NA
Th-228	119	8	7	1.2	2.9	<1	NA	NA
Th-230	119	10	8	1.2	3.44	<1	NA	NA
Th-232	108	0	0	-	-	<1	NA	NA
Th-Total	86	4	5	2	6.14	<3	NA	NA
U-234	118	7	6	1.2	4.2	<1	NA	NA
U-235	3	0	0	-	-	<1	NA	NA
U-235/236	115	0	0	-	-	<1	NA	NA
U-238	118	4	3	0.9	4.4	<1	NA	NA

TABLE E.I-3
(Continued)

Constituent	Total Analyses	Total Detections	Detection Frequency	Minimum Detection	Maximum Detection	Median	Arithmetic Mean	95% UCL on Arithmetic Mean
Inorganic Chemicals (µg/L)								
Aluminum	23	19	83	0.06	0.18	0.087	0.097	0.117
Ammonia	105	36	34	0.1	13	<0.01	0.71	N/A
Antimony	7	1	14	N/A	0.038	<0.03	N/A	N/A
Arsenic	89	24	27	0.002	0.55	<0.002	0.032	N/A
Barium	116	102	88	0.006	0.79	0.05	0.15	0.19
Beryllium	13	7	54	0.001	0.002	0.001	0.001	0.002
Cadmium	114	25	22	0.002	0.017	<0.005	0.003	N/A
Calcium	119	118	99	1.0	181	91	96	101
Chloride	117	102	87	0.02	120	18	24	28
Chromium	120	45	38	0.01	0.56	<0.02	0.02	N/A
Cobalt	13	0	0	<0.01	<0.02	<0.01	N/A	N/A
Copper	120	38	32	0.01	0.27	<0.01	0.019	N/A
Cyanide	5	0	0	<0.002	<0.005	<0.005	N/A	N/A
Fluoride	118	111	94	0.05	1.9	0.27	0.35	0.41
Hexavalent Chromium	2	1	50	N/A	0.05	0.028	N/A	N/A
Iron	119	79	66	0.007	5.5	0.19	1.1	1.4
Lead	83	17	21	0.003	0.14	<0.002	0.006	N/A

4287

0740 E-1-6

TABLE E.I-3
(Continued)

Constituent	Total Analyses	Total Detections	Detection Frequency	Minimum Detection	Maximum Detection	Median	Arithmetic Mean	95% UCL on Arithmetic Mean
Magnesium	118	118	100	0.5	47	27	27	28
Manganese	114	88	77	0.002	0.9	0.05	0.15	0.19
Mercury	112	13	12	0.0002	0.0031	<0.0002	0.0002	N/A
Molybdenum	111	24	22	0.004	0.04	<0.02	0.012	N/A
Nickel	120	20	17	0.012	0.78	<0.02	0.019	N/A
Nitrate	69	57	83	0.014	25	1.0	3.4	4.6
Phosphorous	106	75	71	0.01	3.1	0.05	0.21	0.29
Potassium	113	105	93	0.66	14	1.8	2.1	2.4
Selenium	80	5	6.3	0.002	0.006	<0.002	0.002	N/A
Silicon	10	10	100	2	6.1	3.1	3.6	4.7
Silver	118	19	16	0.01	0.11	<0.01	0.007	N/A
Sodium	114	114	100	0.61	55	12	16	19
Sulfate	118	108	92	2.8	321	48	61	72
Sulfide	14	3	21	0.001	30	<0.05	4.4	N/A
Thallium	7	0	0	<0.001	<0.04	<0.001	N/A	N/A
Tin	3	0	0	N/A	<0.03	<0.03	N/A	N/A
Uranium	113	51	45	0.80	3.1	<1	0.71	0.82
Vanadium	23	19	83	0.01	0.025	0.016	0.015	0.018
Zinc	13	13	100	0.009	3.0	0.037	0.27	0.77

4287
2827

E-I-7

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TABLE E.I-4

**SUMMARY STATISTICS FOR BACKGROUND CONCENTRATIONS
OF INORGANIC CHEMICALS IN SOIL**

Constituent	Frequency of Detection	Range of Detection	Distribution	Sample Arithmetic Mean	Sample Arithmetic Standard Deviation	Sample Geometric Mean	Sample Geometric Standard Deviation	Upper 95% One-sided Confidence Limit on the Sample Mean	Sample Median	95% Confidence Interval on the Sample Median
Aluminum										
0" - 6"	30/30	5350 - 15000	Lognormal	N/A	N/A	7863	1.29	8800	7455	6710 - 8570
36" - 42"	30/30	3300 - 15900	Lognormal	N/A	N/A	8453	1.53	10700	9005	6960 - 10800
48" - 54"	21/21	3250 - 16100	Lognormal	N/A	N/A	7304	1.53	9596	7460	5870 - 9930
Glaciofluvial	17/17	3300 - 16100	Lognormal	N/A	N/A	6767	1.55	9227	6410	5260 - 8350
Till	32/32	4280 - 15900	Lognormal	N/A	N/A	9114	1.41	10813	9800	7770 - 11100
Antimony										
0" - 6"	0/22 ^a	Avg SQL = 7.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
36" - 42"	0/22 ^a	Avg SQL = 6.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
48" - 54"	0/15 ^a	Avg SQL = 6.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Glaciofluvial	0/15 ^a	Avg SQL = 6.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Till	0/21 ^a	Avg SQL = 6.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic										
0" - 6"	26/26	3.40 - 9.20	Lognormal	N/A	N/A	5.18	1.35	6.00	5.05	4.20 - 5.80
36" - 42"	26/26	2.70 - 14.50	Lognormal	N/A	N/A	5.33	1.50	6.72	5.00	4.20 - 5.80
48" - 54"	18/18	1.60 - 8.40	Lognormal	N/A	N/A	4.32	1.54	5.82	4.55	3.90 - 5.50
Glaciofluvial	14/14	3.50 - 10.60	Lognormal	N/A	N/A	5.22	1.34	6.33	5.00	4.00 - 6.00
Till	28/28	1.60 - 14.50	Lognormal	N/A	N/A	4.93	1.57	6.42	4.70	4.10 - 5.80
Barium										
0" - 6"	30/30	31.00 - 331.00	Undefined	N/A	N/A	61.95	1.54	78.93	61.55	48.20 - 69.70
0" - 6" with sus- pected outlier deleted ^b	29/29	31.00 - 94.10	Lognormal	N/A	N/A	58.48	1.35	67.48	59.90	48.20 - 69.70

TABLE E.I-4
(Continued)

4287

Constituent	Frequency of Detection	Range of Detection	Distribution	Sample Arithmetic Mean	Sample Arithmetic Standard Deviation	Sample Geometric Mean	Sample Geometric Standard Deviation	Upper 95% One-sided Confidence Limit on the Sample Mean	Sample Median	95% Confidence Interval on the Sample Median
36" - 42"	30/30	13.70 - 134.00	Lognormal	N/A	N/A	56.30	1.69	77.88	54.40	45.60 - 66.20
48" - 54"	21/21	16.30 - 123.00	Lognormal	N/A	N/A	45.30	1.61	62.00	48.30	38.70 - 55.00
Glaciofluvial	17/17	13.70 - 104.00	Lognormal	N/A	N/A	41.56	1.68	61.84	45.10	32.50 - 54.60
Till	32/32	28.80 - 134.00	Undefined	N/A	N/A	60.44	1.53	76.32	56.85	47.10 - 66.20
Beryllium										
0" - 6"	1/30 ^c	0.60 - 0.60	N/A	N/A	N/A	N/A	N/A	N/A	0.26	N/A
36" - 42"	9/30	0.48 - 0.65	Undefined	N/A	N/A	0.29	1.58	0.37	0.23	0.23 - 0.24
48" - 54"	6/20	0.49 - 0.68	Undefined	N/A	N/A	0.29	1.60	0.40	0.23	0.22 - 0.49
Glaciofluvial	2/17	0.62 - 0.68	Undefined	N/A	N/A	0.24	1.52	0.32	0.23	0.22 - 0.23
Till	13/32	0.48 - 0.65	Undefined	N/A	N/A	0.32	1.57	0.41	0.24	0.23 - 0.52
Boron										
0" - 6"	12/30	12.60 - 1140.00	Undefined	N/A	N/A	10.70	2.71 ^d	N/A	N/A	N/A
0" - 6" with suspected outlier deleted ^e	11/29	12.60 - 25.40	Undefined	N/A	N/A	9.11	1.61	12.07	6.70	6.40 - 13.70
36" - 42"	28/30	18.60 - 47.10	Normal	28.40	9.23	N/A	N/A	31.27	28.65	24.80 - 33.90
48" - 54"	21/21	19.90 - 45.90	Lognormal	N/A	N/A	29.97	1.24	33.41	29.70	25.50 - 35.20
Glaciofluvial	17/17	19.60 - 39.60	Lognormal	N/A	N/A	29.73	1.23	33.34	29.50	25.90 - 35.20
Till	30/32	18.60 - 47.10	Normal	28.58	9.12	N/A	N/A	31.31	28.65	25.50 - 33.90
Cadmium										
0" - 6"	6/29	0.52 - 0.95	Undefined	N/A	N/A	0.32	1.53	0.40	0.26	0.25 - 0.27
36" - 42"	4/29	0.63 - 1.30	Undefined	N/A	N/A	0.27	1.73	0.38	0.23	0.22 - 0.24

E.I-9

0743

TABLE E.I-4
(Continued)

Constituent	Frequency of Detection	Range of Detection	Distribution	Sample Arithmetic Mean	Sample Arithmetic Standard Deviation	Sample Geometric Mean	Sample Geometric Standard Deviation	Upper 95% One-sided Confidence Limit on the Sample Mean	Sample Median	95% Confidence Interval on the Sample Median
36" - 42" with suspected outlier deleted ^f	2/27 ^c	0.63 - 0.91	N/A	N/A	N/A	N/A	N/A	N/A	0.23	N/A
48" - 54"	2/20 ^c	0.47 - 0.59	N/A	N/A	N/A	N/A	N/A	N/A	0.23	N/A
Glaciofluvial	1/17 ^c	0.59 - 0.59	N/A	N/A	N/A	N/A	N/A	N/A	0.23	N/A
Till	5/30	0.47 - 1.30	Undefined	N/A	N/A	0.28	1.68	0.39	0.23	0.23 - 0.24
Till with suspected outlier deleted ^g	3/28	0.47 - 0.91	Undefined	N/A	N/A	0.25	1.42	0.30	0.23	0.23 - 0.24
Calcium										
0" - 6"	30/30	856 - 5340	Lognormal	N/A	N/A	1900	1.65	2580	1760	1410 - 2250
36" - 42"	30/30	3310 - 191000	Undefined	N/A	N/A	53113	3.59 ^h	N/A	93550	67800 - 105000
48" - 54"	21/21	7440 - 335000	Undefined	N/A	N/A	92432	2.05 ^h	N/A	108000	88900 - 117000
Glaciofluvial	17/17	6990 - 150000	Normal	96782	36780	N/A	N/A	112356	105000	85800 - 118000
Till	32/32	3310 - 191000	Undefined	N/A	N/A	55137	3.44 ^h	NA	95650	70600 - 111000
Chromium										
0" - 6"	30/30	6.70 - 17.70	Lognormal	N/A	N/A	10.43	1.27	11.60	9.85	9.00 - 11.10
36" - 42"	30/30	4.60 - 20.00	Lognormal	N/A	N/A	10.95	1.53	13.87	11.55	8.80 - 13.50
48" - 54"	21/21	4.50 - 22.40	Lognormal	N/A	N/A	9.62	1.51	12.46	9.70	7.90 - 13.30
Glaciofluvial	17/17	4.70 - 22.40	Lognormal	N/A	N/A	9.05	1.54	12.21	8.80	7.10 - 10.40
Till	32/32	6.50 - 20.00	Lognormal	N/A	N/A	11.77	1.41	13.93	12.25	9.70 - 13.60
Cobalt										
0" - 6"	30/30	4.30 - 16.50	Lognormal	N/A	N/A	9.66	1.32	10.96	9.70	8.90 - 11.60
36" - 42"	30/30	4.50 - 16.50	Lognormal	N/A	N/A	8.79	1.43	10.56	8.65	7.40 - 10.80

4787

TABLE E.I-4
(Continued)

4787

Constituent	Frequency of Detection	Range of Detection	Distribution	Sample Arithmetic Mean	Sample Arithmetic Standard Deviation	Sample Geometric Mean	Sample Geometric Standard Deviation	Upper 95% One-sided Confidence Limit on the Sample Mean	Sample Median	95% Confidence Interval on the Sample Median
48" - 54"	21/21	3.60 - 17.90	Lognormal	N/A	N/A	8.13	1.49	10.37	8.00	6.60 - 10.30
Glaciofluvial	17/17	4.50 - 14.80	Lognormal	N/A	N/A	7.35	1.40	9.08	7.30	5.90 - 8.80
Till	32/32	4.70 - 17.90	Lognormal	N/A	N/A	9.63	1.38	11.26	9.15	8.20 - 11.40
Copper										
0" - 6"	27/30	3.20 - 17.30	Normal	7.33	4.10	N/A	N/A	8.60	6.25	5.30 - 8.50
36" - 42"	30/30	7.00 - 24.30	Lognormal	N/A	N/A	12.47	1.38	14.63	12.00	10.70 - 14.10
48" - 54"	20/21	6.80 - 16.80	Normal	11.18	3.11	N/A	N/A	12.35	10.20	9.80 - 12.40
Glaciofluvial	17/17	8.40 - 19.00	Lognormal	N/A	N/A	11.17	1.25	12.67	11.00	9.70 - 12.30
Till	32/32	6.80 - 24.30	Lognormal	N/A	N/A	12.58	1.37	14.60	12.80	10.40 - 14.90
Cyanide										
0" - 6"	12/30	0.14 - 0.29	Undefined	N/A	N/A	0.10	1.74	0.14	0.07	0.07 - 0.15
36" - 42"	2/30 ^c	0.17 - 5.60	N/A	N/A	N/A	N/A	N/A	N/A	0.06	N/A
48" - 54"	0/21 ^a	Avg SQL = 0.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Glaciofluvial	1/17 ^c	5.60 - 5.60	N/A	N/A	N/A	N/A	N/A	N/A	0.06	N/A
Till	1/32 ^c	0.17 - 0.17	N/A	N/A	N/A	N/A	N/A	N/A	0.06	N/A
Iron										
0" - 6"	30/30	9370 - 24900	Lognormal	N/A	N/A	14465	1.30	16311	14500	12200 - 16500
36" - 42"	30/30	8970 - 30700	Lognormal	N/A	N/A	18120	1.44	21870	18400	14600 - 22100
48" - 54"	21/21	9360 - 30500	Lognormal	N/A	N/A	16267	1.39	19621	15600	13300 - 21400
Glaciofluvial	17/17	9360 - 29600	Lognormal	N/A	N/A	14858	1.41	18449	13700	11400 - 17600
Till	32/32	10700 - 30700	Lognormal	N/A	N/A	19419	1.36	22461	20150	15800 - 23400
Lead										
0" - 6"	28/28	11.00 - 36.40	Lognormal	N/A	N/A	17.22	1.27	19.22	17.70	14.60 - 18.50

EI-11

0745

TABLE E.I-4
(Continued)

Constituent	Frequency of Detection	Range of Detection	Distribution	Sample Arithmetic Mean	Sample Arithmetic Standard Deviation	Sample Geometric Mean	Sample Geometric Standard Deviation	Upper 95% One-sided Confidence Limit on the Sample Mean	Sample Median	95% Confidence Interval on the Sample Median
0" - 6" with suspected outlier deleted ⁱ	27/27	11.00 - 23.80	Lognormal	N/A	N/A	16.75	1.21	18.21	17.70	14.30 - 18.50
36" - 42"	28/28	5.20 - 18.40	Lognormal	N/A	N/A	9.06	1.42	10.88	8.25	7.40 - 11.30
48" - 54"	19/19	3.00 - 13.00	Lognormal	N/A	N/A	7.34	1.44	9.18	7.00	6.70 - 10.00
Glaciofluvial	15/15	5.20 - 15.20	Lognormal	N/A	N/A	8.19	1.34	9.85	7.60	6.70 - 10.10
Till	30/30	3.60 - 18.40	Lognormal	N/A	N/A	8.80	1.43	10.56	8.10	7.30 - 10.06
Magnesium										
0" - 6"	30/30	1020 - 3590	Undefined	N/A	N/A	1646	1.37	1924	1555	1340 - 1860
36" - 42"	30/30	2930 - 54100	Undefined	N/A	N/A	13848	2.43 ^h	N/A	16300	8120 - 27700
48" - 54"	21/21	5540 - 44100	Normal	23951	11661	N/A	N/A	28340	27600	16300 - 29800
Glaciofluvial	17/17	3370 - 42300	Normal	25215	11262	N/A	N/A	29983	27700	16500 - 32100
Till	32/32	2930 - 44100	Lognormal	N/A	N/A	13245	2.25 ^h	N/A	14300	8120 - 27100
Manganese										
0" - 6"	30/30	189 - 4850	Lognormal	N/A	N/A	650	1.84	983	562	481 - 785
0" - 6" with suspected outlier deleted ^j	29/29	189 - 1500	Lognormal	N/A	N/A	606	1.63	809	543	456 - 785
36" - 42"	30/30	251 - 1410	Lognormal	N/A	N/A	532	1.55	683	510	387 - 621
48" - 54"	21/21	288 - 1750	Undefined	N/A	N/A	468	1.53	613	420	356 - 483
Glaciofluvial	17/17	301 - 1040	Undefined	N/A	N/A	436	1.43	548	406	352 - 472
Till	32/32	288 - 1750	Undefined	N/A	N/A	561	1.56	718	548	378 - 667
Mercury										
0" - 6"	1/30 ^c	0.30 - 0.30	N/A	N/A	N/A	N/A	N/A	N/A	0.07	N/A

4287

0746

E-I-12

TABLE E.I-4
(Continued)

4287

FEMP-01RI-4 DRAFT
October 12, 1993

Constituent	Frequency of Detection	Range of Detection	Distribution	Sample Arithmetic Mean	Sample Arithmetic Standard Deviation	Sample Geometric Mean	Sample Geometric Standard Deviation	Upper 95% One-sided Confidence Limit on the Sample Mean	Sample Median	95% Confidence Interval on the Sample Median
36" - 42"	0/30 ^a	Avg SQL = 0.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
48" - 54"	1/21 ^c	0.29 - 0.29	N/A	N/A	N/A	N/A	N/A	N/A	0.06	N/A
Glaciofluvial	0/17 ^a	Avg SQL = 0.11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Till	1/32 ^c	0.29 - 0.29	N/A	N/A	N/A	N/A	N/A	N/A	0.06	N/A
Molybdenum										
0" - 6"	0/30 ^a	Avg SQL = 2.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
36" - 42"	0/30 ^a	Avg SQL = 2.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
48" - 54"	1/21 ^c	2.70 - 2.70	N/A	N/A	N/A	N/A	N/A	N/A	1.1	N/A
Glaciofluvial	1/17 ^c	2.70 - 2.70	N/A	N/A	N/A	N/A	N/A	N/A	1.1	N/A
Till	0/32 ^a	Avg SQL = 2.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Nickel										
0" - 6"	29/30	5.80 - 22.70	Lognormal	N/A	N/A	9.66	1.60	12.67	9.35	7.30 - 11.90
36" - 42"	30/30	11.00 - 41.90	Lognormal	N/A	N/A	20.10	1.48	24.69	19.55	16.90 - 22.20
48" - 54"	21/21	8.50 - 32.40	Lognormal	N/A	N/A	16.58	1.39	19.99	16.30	13.50 - 19.60
Glaciofluvial	17/17	8.50 - 26.40	Lognormal	N/A	N/A	15.43	1.34	18.34	15.30	12.60 - 17.50
Till	32/32	10.50 - 41.90	Lognormal	N/A	N/A	21.22	1.42	25.28	19.90	17.20 - 24.90
Potassium										
0" - 6"	29/30	374 - 1590	Normal	742	297	N/A	N/A	834	663	561 - 816
36" - 42"	30/30	349 - 2140	Lognormal	N/A	N/A	923	1.56	1186	834	743 - 1160
48" - 54"	21/21	340 - 2180	Lognormal	N/A	N/A	989	1.58	1338	942	753 - 1430
Glaciofluvial	17/17	349 - 2120	Lognormal	N/A	N/A	824	1.53	1111	811	608 - 1090
Till	32/32	587 - 2180	Undefined	N/A	N/A	1074	1.49	1321	1155	796 - 1310

0747

E.I-13

TABLE E.I-4
(Continued)

Constituent	Frequency of Detection	Range of Detection	Distribution	Sample Arithmetic Mean	Sample Arithmetic Standard Deviation	Sample Geometric Mean	Sample Geometric Standard Deviation	Upper 95% One-sided Confidence Limit on the Sample Mean	Sample Median	95% Confidence Interval on the Sample Median
Selenium										
0" - 6"	1/30 ^c	0.72 - 0.72	N/A	N/A	N/A	N/A	N/A	N/A	0.39	N/A
36" - 42"	0/30 ^a	Avg SQL = 0.64	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
48" - 54"	0/21 ^a	Avg SQL = 0.61	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Glaciofluvial	0/17 ^a	Avg SQL = 0.58	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Till	0/32 ^a	Avg SQL = 0.66	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Silicon										
0" - 6"	30/30	15.1 - 2230	Normal	1114	392	N/A	N/A	1235	1085	927 - 1290
0" - 6" with suspected outlier deleted ^k	29/29	480 - 2230	Lognormal	N/A	N/A	1105	1.34	1273	1110	927 - 1310
36" - 42"	30/30	449 - 1540	Lognormal	N/A	N/A	945	1.33	1081	990	795 - 1080
48" - 54"	21/21	467 - 1850	Lognormal	N/A	N/A	892	1.48	1130	846	722 - 1270
Glaciofluvial	17/17	539 - 1850	Lognormal	N/A	N/A	829	1.38	1016	794	723 - 879
Till	32/32	449 - 1540	Lognormal	N/A	N/A	1009	1.35	1162	1050	951 - 1260
Silver										
0" - 6"	0/30 ^a	Avg SQL = 2.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
36" - 42"	0/30 ^a	Avg SQL = 2.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
48" - 54"	0/21 ^a	Avg SQL = 2.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Glaciofluvial	0/17 ^a	Avg SQL = 2.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Till	0/32 ^a	Avg SQL = 2.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sodium										
0" - 6"	27/30	26.90 - 54.70	Normal	34.34	10.19	N/A	N/A	37.50	33.95	30.70 - 38.60
36" - 42"	30/30	53.80 - 305.00	Lognormal	N/A	N/A	118.78	1.51	149.32	109.50	103.00 - 138.00

TABLE E.I-4
(Continued)

4782
2827

Constituent	Frequency of Detection	Range of Detection	Distribution	Sample Arithmetic Mean	Sample Arithmetic Standard Deviation	Sample Geometric Mean	Sample Geometric Standard Deviation	Upper 95% One-sided Confidence Limit on the Sample Mean	Sample Median	95% Confidence Interval on the Sample Median
48" - 54"	21/21	90.40 - 345.00	Undefined	N/A	N/A	129.00	1.34	151.31	129.00	108.00 - 135.00
Glaciofluvial	17/17	64.30 - 345.00	Undefined	N/A	N/A	118.71	1.40	146.70	111.00	102.00 - 131.00
Till	32/32	53.80 - 305.00	Lognormal	N/A	N/A	125.31	1.49	154.13	117.00	107.00 - 143.00
Thallium										
0" - 6"	1/30 ^c	0.58 - 0.58	N/A	N/A	N/A	N/A	N/A	N/A	0.26	N/A
36" - 42"	3/30 ^c	0.49 - 0.55	N/A	N/A	N/A	N/A	N/A	N/A	0.23	N/A
48" - 54"	0/21 ^a	Avg SQL = 0.43	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Glaciofluvial	0/17 ^a	Avg SQL = 0.42	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Till	3/32 ^c	0.49 - 0.55	N/A	N/A	N/A	N/A	N/A	N/A	0.23	N/A
Till with suspected outlier deleted ¹	1/30 ^c	0.49 - 0.49	N/A	N/A	N/A	N/A	N/A	N/A	0.23	N/A
Vanadium										
0" - 6"	30/30	11.30 - 32.70	Lognormal	N/A	N/A	19.76	1.30	22.25	19.20	17.60 - 23.60
36" - 42"	30/30	8.70 - 44.50	Lognormal	N/A	N/A	18.00	1.61	23.78	15.10	13.60 - 25.50
48" - 54"	21/21	8.40 - 40.20	Undefined	N/A	N/A	15.82	1.62	21.83	13.30	11.40 - 24.10
Glaciofluvial	17/17	8.40 - 40.20	Lognormal	N/A	N/A	15.42	1.60	21.69	13.10	11.90 - 23.80
Till	32/32	10.40 - 44.50	Undefined	N/A	N/A	18.76	1.59	24.30	16.15	13.60 - 25.60
Zinc										
0" - 6"	30/30	29.40 - 70.00	Undefined	N/A	N/A	39.99	1.27	44.55	38.90	34.50 - 42.90
36" - 42"	30/30	27.30 - 101.00	Lognormal	N/A	N/A	49.30	1.35	57.11	48.00	40.20 - 53.90
48" - 54"	21/21	33.30 - 67.70	Lognormal	N/A	N/A	44.95	1.18	48.62	45.00	39.90 - 47.80
Glaciofluvial	17/17	35.40 - 69.40	Undefined	N/A	N/A	43.26	1.20	47.57	43.70	37.90 - 45.80
Till	32/32	33.30 - 101.00	Lognormal	N/A	N/A	51.08	1.30	57.50	48.50	42.20 - 53.90

TABLE EI-4
(Continued)

^aWhen all of the values in the data set were not detectable, one-half of the SQL was the best representative value for the mean and the SQL was the best representative value for the UTL.

^bThe Barium (0-6) result in sample number 61692 was identified as a statistical outlier and was excluded from this data set.

^cWhen less than or equal to 10% of measured concentrations were above the SQL, only the range of detection and sample median were presented.

^dCalculated geometric standard deviation was greater than 2.00. This was caused by the combination of only 12 values out of 30 above SQL and the maximum concentration of 1140 g/g.

Summary statistics for "0-6" without suspected outlier was used as the representative statistics for this data set.

^eThe Boron (0-6) result in sample number 61666 was identified as a statistical outlier and was excluded from this data set.

^fThe Cadmium (36-42) result in sample numbers 61697 and 61642 was identified as a statistical outlier and was excluded from this data set.

^gThe Cadmium (Till) result in sample numbers 61697 and 61642 was identified as a statistical outlier and was excluded from this data set.

^hWhen the calculated geometric standard deviation was greater than 2.00, the median, 95% confidence interval on the median and maximum measured concentration for UTL were used as the best representative statistics for the data set.

ⁱThe Lead (0-6) result in sample number 61698 was identified as a statistical outlier and was excluded from this data set.

^jThe Manganese (0-6) result in sample number 61692 was identified as a statistical outlier and was excluded from this data set.

^kThe Silicon (0-6) result in sample number 61666 was identified as a statistical outlier and was excluded from this data set.

^lThe Thallium (Till) result in sample numbers 61709 and 61657 was identified as a statistical outlier and was excluded from this data set.

0750

E-I-16

4289

TABLE E.I-5
SUMMARY STATISTICS FOR BACKGROUND CONCENTRATIONS OF RADIOLOGICAL CONSTITUENTS

Constituent	Frequency of Detection	Range of Detection	Distribution	Sample Arithmetic Mean	Sample Arithmetic Standard Deviation	Sample Geometric Mean	Sample Geometric Standard Deviation	Upper 95% One-sided Confidence Limit on the Sample Mean	Sample Median	95% Confidence Interval on the Sample Median
Actinium 227										
0" - 6"	1/30 ^a	0.09 - 0.09	N/A	N/A	N/A	N/A	N/A	N/A	0.025	N/A
36" - 42"	2/30 ^a	0.08 - 0.10	N/A	N/A	N/A	N/A	N/A	N/A	0.020	N/A
48" - 54"	1/21 ^a	0.06 - 0.06	N/A	N/A	N/A	N/A	N/A	N/A	0.020	N/A
Glaciofluvial	1/17 ^a	0.08 - 0.08	N/A	N/A	N/A	N/A	N/A	N/A	0.020	N/A
Till	2/32 ^a	0.06 - 0.10	N/A	N/A	N/A	N/A	N/A	N/A	0.020	N/A
Cesium 137										
0" - 6"	30/30 ^b	0.15 - 0.71	Lognormal	N/A	N/A	0.341	1.563	0.440	0.33	0.25 - 0.49
36" - 42"	0/30 ^b	Avg SQL = 0.10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
48" - 54"	0/21 ^b	Avg SQL = 0.10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Glaciofluvial	0/17 ^b	Avg SQL = 0.10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Till	0/32 ^b	Avg SQL = 0.10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lead 210										
0" - 6"	30/30	0.53 - 1.30	Lognormal	N/A	N/A	0.904	1.264	1.003	0.89	0.84 - 1.03
36" - 42"	26/30	0.31 - 0.83	Undefined	N/A	N/A	0.473	1.681	0.652	0.55	0.48 - 0.63
48" - 54"	17/21	0.44 - 0.97	Undefined	N/A	N/A	0.446	1.768	0.676	0.52	0.46 - 0.63
Glaciofluvial	15/17	0.31 - 0.97	Lognormal	N/A	N/A	0.461	1.617	0.653	0.50	0.47 - 0.55
Till	26/32	0.31 - 0.83	Undefined	N/A	N/A	0.454	1.787	0.655	0.56	0.44 - 0.64

**TABLE E.I-5
(Continued)**

Constituent	Frequency of Detection	Range of Detection	Distribution	Sample Arithmetic Mean	Sample Arithmetic Standard Deviation	Sample Geometric Mean	Sample Geometric Standard Deviation	Upper 95% One-sided Confidence Limit on the Sample Mean	Sample Median	95% Confidence Interval on the Sample Median
Potassium 40										
0" - 6"	30/30	13.10 - 21.40	Lognormal	N/A	N/A	16.129	1.130	16.888	15.80	15.40 - 16.60
36" - 42"	30/30	9.27 - 30.20	Lognormal	N/A	N/A	16.417	1.365	19.114	16.30	14.30 - 18.80
48" - 54"	21/21	8.60 - 31.00	Lognormal	N/A	N/A	16.420	1.402	19.969	16.10	14.20 - 20.20
Glaciofluvial	17/17	9.27 - 21.20	Normal	14.835	4.057	N/A	N/A	16.553	15.90	11.40 - 17.40
Till	32/32	8.60 - 31.00	Lognormal	N/A	N/A	18.087	1.359	20.911	17.10	15.70 - 22.40
Protactinium 231										
0" - 6"	0/30 ^a	Avg SQL = 0.31	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
36" - 42"	0/30 ^a	Avg SQL = 0.26	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
48" - 54"	0/21 ^a	Avg SQL = 0.25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Glaciofluvial	0/17 ^a	Avg SQL = 0.22	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Till	0/32 ^a	Avg SQL = 0.28	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Radium 224										
0" - 6"	30/30	0.54 - 0.93	Undefined	N/A	N/A	0.798	1.135	0.837	0.84	0.77 - 0.86
36" - 42"	30/30	0.30 - 1.07	Lognormal	N/A	N/A	0.589	1.418	0.703	0.58	0.51 - 0.68
48" - 54"	21/21	0.29 - 0.96	Lognormal	N/A	N/A	0.550	1.405	0.670	0.54	0.47 - 0.67
Glaciofluvial	17/17	0.29 - 0.87	Lognormal	N/A	N/A	0.491	1.392	0.605	0.52	0.38 - 0.59
Till	32/32	0.31 - 1.07	Lognormal	N/A	N/A	0.635	1.376	0.741	0.62	0.51 - 0.81
Radium 226										
0" - 6"	30/30	0.85 - 1.48	Lognormal	N/A	N/A	1.168	1.141	1.228	1.19	1.12 - 1.24
36" - 42"	30/30	0.59 - 1.61	Undefined	N/A	N/A	0.901	1.307	1.019	0.83	0.77 - 0.94
48" - 54"	21/21	0.63 - 1.38	Undefined	N/A	N/A	0.841	1.209	0.921	0.76	0.76 - 0.91

TABLE E.I-5
(Continued)

Constituent	Frequency of Detection	Range of Detection	Distribution	Sample Arithmetic Mean	Sample Arithmetic Standard Deviation	Sample Geometric Mean	Sample Geometric Standard Deviation	Upper 95% One-sided Confidence Limit on the Sample Mean	Sample Median	95% Confidence Interval on the Sample Median
Glaciofluvial	17/17	0.63 - 1.29	Undefined	N/A	N/A	0.823	1.216	0.914	0.77	0.75 - 0.89
Till	32/32	0.59 - 1.61	Undefined	N/A	N/A	0.916	1.293	1.028	0.85	0.78 - 0.94
Radium 228										
0" - 6"	30/30	0.80 - 1.27	Undefined	N/A	N/A	1.053	1.123	1.100	1.09	1.03 - 1.14
36" - 42"	30/30	0.40 - 1.37	Lognormal	N/A	N/A	0.755	1.432	0.907	0.73	0.67 - 0.86
48" - 54"	21/21	0.36 - 1.27	Lognormal	N/A	N/A	0.701	1.419	0.860	0.71	0.59 - 0.83
Glaciofluvial	17/17	0.40 - 1.16	Lognormal	N/A	N/A	0.630	1.394	0.777	0.68	0.46 - 0.75
Till	32/32	0.36 - 1.37	Lognormal	N/A	N/A	0.812	1.396	0.955	0.78	0.67 - 1.04
Ruthenium 106										
0" - 6"	0/30 ^b	Avg SQL = 0.07	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
36" - 42"	0/30 ^b	Avg SQL = 0.06	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
48" - 54"	0/21 ^b	Avg SQL = 0.06	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Glaciofluvial	0/17 ^b	Avg SQL = 0.06	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Till	0/32 ^b	Avg SQL = 0.07	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Strontium 90										
0" - 6"	0/30 ^b	Avg SQL = 0.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
36" - 42"	0/30 ^b	Avg SQL = 0.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
48" - 54"	1/21 ^b	0.56 - 0.56	N/A	N/A	N/A	N/A	N/A	N/A	0.25	N/A
Glaciofluvial	0/17 ^b	Avg SQL = 0.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Till	1/32 ^b	0.56 - 0.56	N/A	N/A	N/A	N/A	N/A	N/A	0.25	N/A
Technetium 99										
0" - 6"	0/30 ^b	Avg SQL = 0.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE E.I-5
(Continued)

Constituent	Frequency of Detection	Range of Detection	Distribution	Sample Arithmetic Mean	Sample Arithmetic Standard Deviation	Sample Geometric Mean	Sample Geometric Standard Deviation	Upper 95% One-sided Confidence Limit on the Sample Mean	Sample Median	95% Confidence Interval on the Sample Median
36" - 42"	0/30 ^b	Avg SQL = 0.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
48" - 54"	0/21 ^b	Avg SQL = 0.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Glaciofluvial	0/17 ^b	Avg SQL = 0.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Till	0/32 ^b	Avg SQL = 0.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Thorium 228										
0" - 6"	29/30	0.68 - 1.43	Normal	1.047	0.231	N/A	N/A	1.119	1.04	0.99 - 1.10
36" - 42"	25/30	0.60 - 1.39	Normal	0.856	0.320	N/A	N/A	0.955	0.86	0.72 - 0.99
48" - 54"	16/21	0.63 - 1.25	Normal	0.739	0.311	N/A	N/A	0.856	0.76	0.66 - 0.87
Glaciofluvial	12/17	0.66 - 1.25	Undefined	N/A	N/A	0.598	1.629	0.854	0.71	0.30 - 0.79
Till	28/32	0.60 - 1.39	Normal	0.906	0.301	N/A	N/A	0.997	0.90	0.79 - 1.08
Thorium 230										
0" - 6"	29/30	0.90 - 2.01	Normal	1.385	0.356	N/A	N/A	1.496	1.42	1.25 - 1.57
36" - 42"	26/30	0.62 - 2.34	Normal	1.117	0.486	N/A	N/A	1.268	1.09	0.90 - 1.32
48" - 54"	19/21	0.75 - 2.02	Normal	1.152	0.422	N/A	N/A	1.311	1.13	1.02 - 1.29
Glaciofluvial	16/17	0.75 - 1.53	Normal	1.068	0.285	N/A	N/A	1.189	1.10	0.99 - 1.20
Till	27/32	0.62 - 2.34	Normal	1.175	0.537	N/A	N/A	1.336	1.20	0.96 - 1.45
Thorium 232										
0" - 6"	30/30	0.64 - 1.52	Lognormal	N/A	N/A	0.998	1.208	1.079	1.01	0.92 - 1.07
36" - 42"	20/30	0.68 - 1.35	Undefined	N/A	N/A	0.640	1.723	0.902	0.77	0.50 - 0.91
48" - 54"	16/21	0.63 - 1.30	Normal	0.731	0.307	N/A	N/A	0.846	0.71	0.63 - 0.86
Glaciofluvial	9/17	0.63 - 1.00	Undefined	N/A	N/A	0.501	1.675	0.743	0.63	0.30 - 0.74
Till	27/32	0.63 - 1.35	Normal	0.843	0.295	N/A	N/A	0.931	0.85	0.75 - 0.95

TABLE E.I-5
(Continued)

Constituent	Frequency of Detection	Range of Detection	Distribution	Sample Arithmetic Mean	Sample Arithmetic Standard Deviation	Sample Geometric Mean	Sample Geometric Standard Deviation	Upper 95% One-sided Confidence Limit on the Sample Mean	Sample Median	95% Confidence Interval on the Sample Median
Total Thorium										
0" - 6"	N/A	N/A	N/A	N/A	N/A	9.073 mg/kg ^c	N/A	N/A	N/A	N/A
36" - 42"	N/A	N/A	N/A	N/A	N/A	5.818 mg/kg ^c	N/A	N/A	N/A	N/A
48" - 54"	N/A	N/A	N/A	6.646 mg/kg ^c	N/A	N/A	N/A	N/A	N/A	N/A
Glaciofluvial	N/A	N/A	N/A	N/A	N/A	4.555 mg/kg ^c	N/A	N/A	N/A	N/A
Till	N/A	N/A	N/A	7.664 mg/kg ^c	N/A	N/A	N/A	N/A	N/A	N/A
Uranium 234										
0" - 6"	30/30	0.67 - 1.31	Lognormal	N/A	N/A	0.979	1.157	1.036	0.99	0.91 - 1.07
36" - 42"	28/30	0.48 - 1.30	Normal	0.742	0.209	N/A	N/A	0.807	0.71	0.69 - 0.77
48" - 54"	19/21	0.50 - 0.93	Normal	0.674	0.163	N/A	N/A	0.735	0.70	0.61 - 0.74
Glaciofluvial	13/17	0.62 - 1.08	Undefined	N/A	N/A	0.601	1.517	0.802	0.70	0.62 - 0.73
Till	32/32	0.48 - 1.30	Lognormal	N/A	N/A	0.741	1.235	0.809	0.72	0.68 - 0.80
Uranium 235/236										
0" - 6"	27/30	0.03 - 0.20	Lognormal	N/A	N/A	0.066	1.638	0.088	0.07	0.05 - 0.08
36" - 42"	27/30	0.03 - 0.20	Lognormal	N/A	N/A	0.057	1.812	0.084	0.06	0.05 - 0.07
48" - 54"	19/21	0.03 - 0.15	Lognormal	N/A	N/A	0.057	1.617	0.08	0.05	0.04 - 0.08
Glaciofluvial	13/17	0.04 - 0.15	Lognormal	N/A	N/A	0.045	1.775	0.072	0.05	0.04 - 0.06
Till	31/32	0.03 - 0.20	Lognormal	N/A	N/A	0.064	1.661	0.086	0.06	0.05 - 0.08
Uranium 238										
0" - 6"	30/30	0.85 - 1.33	Lognormal	N/A	N/A	1.039	1.103	1.077	1.03	1.01 - 1.08
36" - 42"	29/30	0.62 - 1.23	Normal	0.832	0.198	N/A	N/A	0.894	0.79	0.74 - 0.92
48" - 54"	19/21	0.60 - 1.04	Undefined	N/A	N/A	0.723	1.373	0.865	0.82	0.70 - 0.84

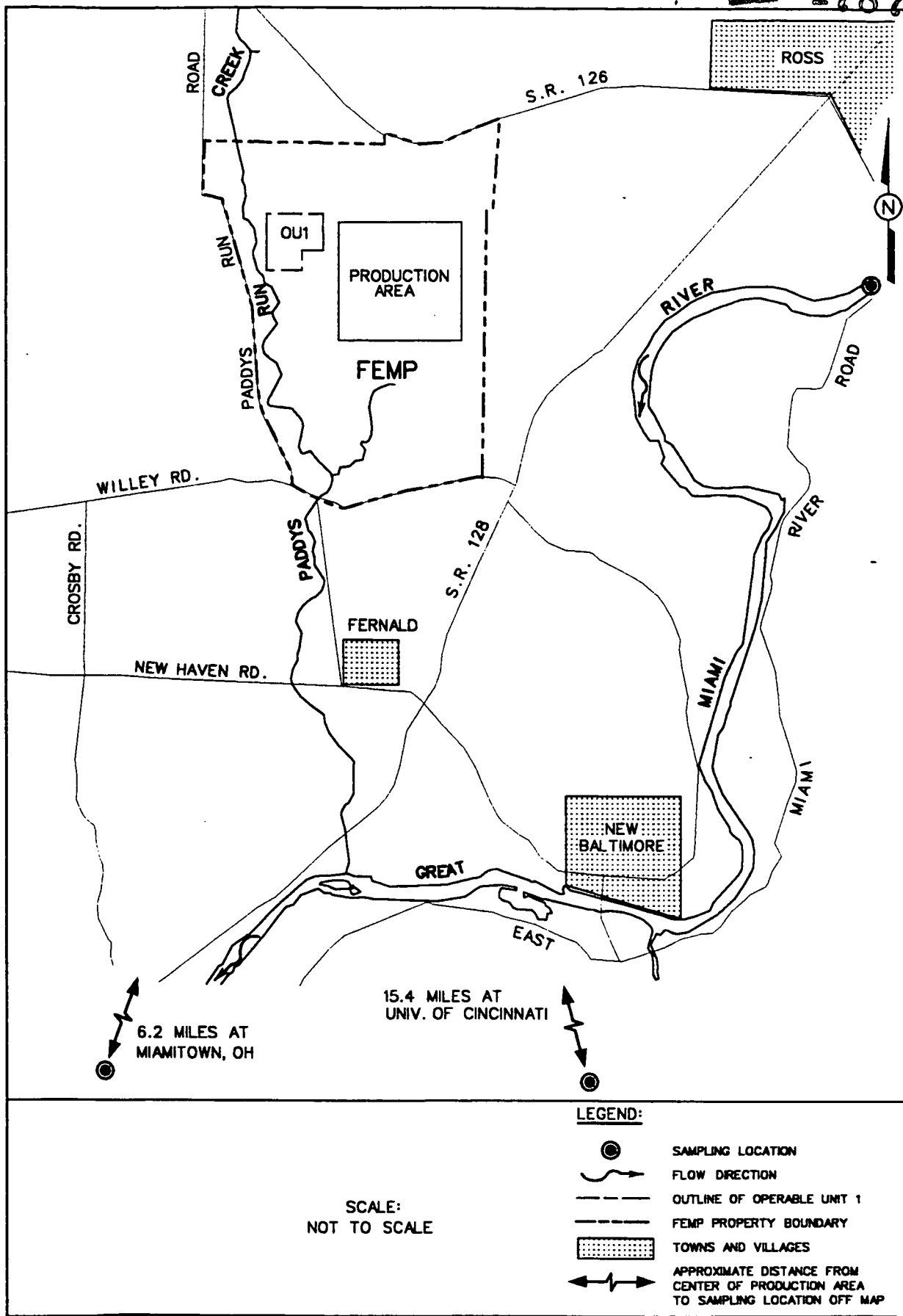
TABLE E.I-5
(Continued)

Constituent	Frequency of Detection	Range of Detection	Distribution	Sample Arithmetic Mean	Sample Arithmetic Standard Deviation	Sample Geometric Mean	Sample Geometric Standard Deviation	Upper 95% One-sided Confidence Limit on the Sample Mean	Sample Median	95% Confidence Interval on the Sample Median
Glaciofluvial	14/17	0.62 - 1.23	Undefined	N/A	N/A	0.665	1.504	0.882	0.74	0.68 - 0.83
Till	32/32	0.64 - 1.23	Lognormal	N/A	N/A	0.841	1.185	0.899	0.84	0.76 - 0.92
Total Uranium										
0" - 6"	N/A	N/A	N/A	N/A	N/A	3.123 mg/kg ^c	N/A	N/A	N/A	N/A
36" - 42"	N/A	N/A	N/A	2.503 mg/kg ^c	N/A	N/A	N/A	N/A	N/A	N/A
48" - 54"	N/A	N/A	N/A	N/A	N/A	2.178 mg/kg ^c	N/A	N/A	N/A	N/A
Glaciofluvial	N/A	N/A	N/A	N/A	N/A	2.000 mg/kg ^c	N/A	N/A	N/A	N/A
Till	N/A	N/A	N/A	N/A	N/A	2.533 mg/kg ^c	N/A	N/A	N/A	N/A

^aWhen less than or equal to 10% of measured concentrations were above the SQL, only the range of detection and sample medial were presented.

^bThis radionuclide is a fission product and its presence in the environment is due only to atmospheric releases of radiation (e.g., weapons testing). This radionuclide is not naturally occurring and is only expected to be present at or near detectable activities in the surface soil.

^cIndividual activities of the three isotopes for uranium and thorium were converted to weight percents. The three isotope weight percents for each radionuclide were added to obtain total thorium or uranium.



40951-A-254 /DUJ /KNOX /DS
4095254.DUJ CP 08/10/83

FIGURE E.I-1. SURFACE WATER BACKGROUND SAMPLING LOCATION FOR OPERABLE UNIT 1

0757

LIST OF TABLES

<u>Table</u>	<u>Title</u>	<u>Page</u>
E.II-1	Pit 1 Material Analytical Results	E.II-2
E.II-2	Pit 2 Material Analytical Results	E.II-14
E.II-3	Pit 3 Material Analytical Results	E.II-26
E.II-4	Pit 4 Material Analytical Results	E.II-37
E.II-5	Pit 5 Material Analytical Results	E.II-48
E.II-6	Pit 6 Analytical Results	E.II-55
E.II-7	Burn Pit Material Analytical Result	E.II-65
E.II-8	Clearwell Material Analytical Results	E.II-78
E.II-9	Pit 1 Material Analysis for Radionuclides	E.II-86
E.II-10	Pit 2 Material Analysis for Radionuclides	E.II-87
E.II-11	Pit 3 Material Analysis for Radionuclides	E.II-88
E.II-12	Pit 4 Material Analysis for Radionuclides	E.II-89
E.II-13	Pit 5 Material Analysis for Radionuclides	E.II-90
E.II-14	Pit 6 Material Analysis for Radionuclides	E.II-91
E.II-15	Burn Pit Material Analysis for Radionuclides	E.II-92
E.II-16	Clearwell Material Analysis for Radionuclides	E.II-93
E.II-17	Surface Soil - Analysis for Radionuclides	E.II-94
E.II-18	Surface Soil - Analysis for Chemicals	E.II-95
E.II-19	Pit 5 Surface Water - Analysis for Radionuclides	E.II-98
E.II-20	Pit 5 Surface Water - Analysis for Chemicals	E.II-99
E.II-21	Pit 6 Surface Water - Analysis for Radionuclides	E.II-107
E.II-22	Pit 6 Surface Water - Analysis for Chemicals	E.II-108
E.II-23	Clearwell Surface Water - Analysis for Radionuclides	E.II-116
E.II-24	Clearwell Surface Water - Analysis for Chemicals	E.II-117

4787

ATTACHMENT E.II

Screening of Constituents of Potential Concern

This attachment presents the screening assessment used for determination of constituents of potential concern (CPCs) for use in the quantitative baseline risk assessment. The methodologies for screening of CPCs is discussed in detail in Appendix E, Section E.II. Below is the legend used in this attachment that provides justification for elimination of a constituent as a CPC.

LEGEND

- A: Not Detected.
 - B: Potential laboratory artifact - not site related. Risks are minor in comparison with other CPCs retained.
 - C: Nutrient (human).
 - D: Low toxicity compound or detected at concentrations less than 1 mg/kg.
 - E: Laboratory artifact - chemical used in uranium extraction procedure.
 - F: Site characterization data not appropriate for risk assessment.
 - G: Evaluates soil nitrogen - not appropriate for risk assessment.
 - H: Ubiquitous soil mineral.
 - I: Doubtful compound; insufficient data.
 - J: Compound not retained - no specific TEF for this congener (EPA 1989j).
 - K: Thorium has no known toxic effects. Evaluated as a radiocarcinogen.
- All concentrations were calculated using a normalized distribution of the UCL.

TABLE E.II-1

PIT 1 MATERIAL ANALYTICAL RESULTS

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
N-Nitrosodipropylamine	0/1		ND	ug/kg					A
Phosphoric acid, Tributyl ester	1/1	28000	-	ug/kg					E
1,2,3,4,6,7,8-Heptachlorodibenzo-p-					5/6	1.2	0.77	ng/g	Retained
1,2,3,4,6,7,8-Heptachlorodibenzofuran					5/6	1.2	0.80	ng/g	Retained
1,2,3,4,7,8,9-Heptachlorodibenzofuran					0/6		ND	ng/g	A
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin					0/6		ND	ng/g	A
1,2,3,4,7,8-Hexachlorodibenzofuran					3/6	0.83	0.66	ng/g	Retained
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin					4/6	0.77	0.52	ng/g	Retained
1,2,3,6,7,8-Hexachlorodibenzofuran					3/6	0.29	0.23	ng/g	Retained
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin					3/6	0.53	0.34	ng/g	Retained
1,2,3,7,8,9-Hexachlorodibenzofuran					0/6		ND	ng/g	A
1,2,3,7,8-Pentachlorodibenzo-p-dioxin					0/6		ND	ng/g	A
1,2,3,7,8-Pentachlorodibenzofuran					5/6	1.2	0.73	ng/g	Retained
2,3,4,6,7,8-Hexachlorodibenzofuran					3/6	0.41	0.32	ng/g	Retained
2,3,4,7,8-Pentachlorodibenzofuran					4/6	1.2	0.75	ng/g	Retained
2,3,7,8-TCDD					0/6		ND	ng/g	A
2,3,7,8-TCDF					5/6	14	7.64	ng/g	Retained
Heptachlorodibenzo-p-dioxin					5/6	2.3	1.45	ng/g	Retained
Heptachlorodibenzofuran					5/6	2.7	1.75	ng/g	Retained
Hexachlorodibenzo-p-dioxin					5/6	4.9	3.21	ng/g	Retained
Hexachlorodibenzofuran					4/6	2.9	2.26	ng/g	Retained
Octachlorodibenzo-p-dioxin					5/6	0.74	0.54	ng/g	Retained
Octachlorodibenzofuran					3/6	0.76	0.46	ng/g	Retained
Pentachlorodibenzo-p-dioxin					0/6		ND	ng/g	A
Pentachlorodibenzofuran					5/6	7.9	4.69	ng/g	Retained

E-II-2

TABLE E.II-1
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Tetrachlorodibenzo-p-dioxin					0/6		ND	ng/g	A
Tetrachlorodibenzofuran					6/6	35	20.74	ng/g	Retained
Ammonia					1/1	48		mg/kg	G
Phosphorus					1/1	6.73		mg/kg	C
Sulfide					0/2		ND	mg/kg	A
Total kjeldahl nitrogen					1/1	47.7		mg/kg	F
Total organic carbon					3/3	33600	46327.65	mg/kg	F
Total organic nitrogen					0/1		ND	mg/kg	A
2,4,5-T					0/5		ND	ug/kg	A
2,4,5-TP (SILVEX)					0/5		ND	ug/kg	A
2,4-D					0/5		ND	ug/kg	A
Dinoseb					0/6		ND	ug/kg	A
Aluminum	6/6	20200	15129.759	mg/kg	6/6	4690	3540.66	mg/kg	C
Antimony	1/6	0.4	0.9630366	mg/kg	6/6	125	88.86	mg/kg	Retained
Arsenic	6/6	15	11.306187	mg/kg	5/6	1.7	1.70	mg/kg	Retained
Barium	6/6	395	373.81221	mg/kg	6/6	439	405.26	mg/kg	Retained
Beryllium	5/6	2.2	1.8110180	mg/kg	6/6	12.5	8.21	mg/kg	Retained
Boron					4/5	1650	1220.93	mg/kg	Retained
Cadmium	5/6	5	3.3207955	mg/kg	6/6	18.5	16.17	mg/kg	Retained
Calcium	1/6	4760	58997.826	mg/kg	6/6	197000	144955.30	mg/kg	C
Chromium	6/6	46	30.105842	mg/kg	6/6	347	225.50	mg/kg	Retained
Cobalt	3/6	28	16.692645	mg/kg	6/6	46.8	33.76	mg/kg	Retained
Copper	1/6	20	47.157797	mg/kg	6/6	113	80.03	mg/kg	Retained
Cyanide	0/6		ND	mg/kg	3/6	0.73	0.45	mg/kg	Retained
Iron	6/6	19700	13106.454	mg/kg	6/6	2610	2121.38	mg/kg	C

TABLE E.II-1
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Lead	1/6	17	28.699116	mg/kg	5/5	53.4	36.61	mg/kg	Retained
Magnesium	1/6	7610	17383.444	mg/kg	6/6	129000	111801.88	mg/kg	C
Manganese	6/6	2910	2128.4569	mg/kg	6/6	3720	2036.51	mg/kg	Retained
Mercury	1/6	0.3	0.1822620	mg/kg	0/6		ND	mg/kg	Retained
Molybdenum					6/6	32.7	25.66	mg/kg	Retained
Nickel	6/6	65	41.796909	mg/kg	6/6	57.4	47.05	mg/kg	Retained
Potassium	6/6	2560	2209.7428	mg/kg	6/6	1210	890.18	mg/kg	C
Selenium	0/6		ND	mg/kg	0/6		ND	mg/kg	A
Silicon					5/5	7190	5832.72	mg/kg	H
Silver	4/6	33	17.836738	mg/kg	6/6	189	122.46	mg/kg	Retained
Sodium	5/6	3640	2372.7190	mg/kg	5/6	1930	1300.89	mg/kg	H
Thallium	1/6	0.3	0.2228623	mg/kg	1/6	0.46	0.35	mg/kg	Retained
Tin					0/5		ND	mg/kg	A
Vanadium	6/6	67	48.267723	mg/kg	6/6	142	95.71	mg/kg	Retained
Zinc	4/6	58	36.656890	mg/kg	6/6	24.9	19.31	mg/kg	Retained
Azinphosmethyl					0/1		ND	ug/kg	A
Demeton					0/1		ND	ug/kg	A
Diazinon					0/1		ND	ug/kg	A
Dimethoate					0/5		ND	ug/kg	A
Disulfoton					0/5		ND	ug/kg	A
Ethion					0/1		ND	ug/kg	A
Famphur					0/5		ND	ug/kg	A
Malathion					0/1		ND	ug/kg	A
Parathion, Ethyl					0/5		ND	ug/kg	A
Parathion, Methyl					0/5		ND	ug/kg	A

0762

E-II-4

1070

4282

TABLE E.II-1
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Phorate					0/5		ND	ug/kg	A
Sulfotepp					0/6		ND	ug/kg	A
Tetraethylpyrophosphate					0/5		ND	ug/kg	A
Thionazin					0/5		ND	ug/kg	A
4,4'-DDD	0/6		ND	ug/kg	0/5		ND	ug/kg	A
4,4'-DDE	0/6		ND	ug/kg	0/5		ND	ug/kg	A
4,4'-DDT	1/6	1600	934.39873	ug/kg	0/5		ND	ug/kg	Retained
Aldrin	0/6		ND	ug/kg	0/5		ND	ug/kg	A
alpha-BHC	0/6		ND	ug/kg	0/5		ND	ug/kg	A
alpha-Chlordane					0/5		ND	ug/kg	A
Aroclor-1016	0/6		ND	ug/kg	0/5		ND	ug/kg	A
Aroclor-1221	0/6		ND	ug/kg	1/5	4600	4124.61	ug/kg	Retained
Aroclor-1232	0/6		ND	ug/kg	0/5		ND	ug/kg	A
Aroclor-1242	0/6		ND	ug/kg	0/5		ND	ug/kg	A
Aroclor-1248	1/6	3500	2541.3015	ug/kg	5/6	10000	7065.85	ug/kg	Retained
Aroclor-1254	6/6	11500	9978.4540	ug/kg	5/5	10000	9253.89	ug/kg	Retained
Aroclor-1260	2/6	7800	6109.6519	ug/kg	0/5		ND	ug/kg	A
beta-BHC	0/6		ND	ug/kg	0/5		ND	ug/kg	A
Chlordane	0/6		ND	ug/kg					A
Chlorobenzilate					0/3		ND	ug/kg	A
delta-BHC	0/6		ND	ug/kg	0/5		ND	ug/kg	A
Dieldrin	0/6		ND	ug/kg	0/5		ND	ug/kg	A
Endosulfan I	0/6		ND	ug/kg					A
Endosulfan II	0/6		ND	ug/kg	0/5		ND	ug/kg	A
Endosulfan Sulfate	0/6		ND	ug/kg	0/5		ND	ug/kg	A

0763 E-II-5

4282

TABLE E.II-1
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Endosulfan-I					0/5		ND	ug/kg	A
Endrin	0/6		ND	ug/kg	0/5		ND	ug/kg	A
Endrin Ketone	0/6		ND	ug/kg	0/5		ND	ug/kg	A
gamma-BHC (Lindane)					0/5		ND	ug/kg	A
gamma-BHC (Lindane)	0/6		ND	ug/kg					A
gamma-Chlordane					0/5		ND	ug/kg	A
Heptachlor	0/6		ND	ug/kg	0/5		ND	ug/kg	A
Heptachlor Epoxide	0/6		ND	ug/kg	0/5		ND	ug/kg	A
Isodrin					0/3		ND	ug/kg	A
Kepone					0/3		ND	ug/kg	A
Methoxychlor	0/6		ND	ug/kg	0/5		ND	ug/kg	A
Toxaphene	0/6		ND	ug/kg	0/5		ND	ug/kg	A
1,2,4,5-Tetrachlorobenzene					0/3		ND	ug/kg	A
1,2,4-Trichlorobenzene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
1,2-Dichlorobenzene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
1,3,5-Trinitrobenzene					0/2		ND	ug/kg	A
1,3-Dichlorobenzene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
1,3-Dinitrobenzene					0/3		ND	ug/kg	A
1,4-Dichlorobenzene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
1,4-Naphthoquinone					0/4		ND	ug/kg	A
1-Naphthylamine					0/3		ND	ug/kg	A
2,3,4,6-Tetrachlorophenol					0/3		ND	ug/kg	A
2,4,5-Trichlorophenol	0/6		ND	ug/kg	0/8		ND	ug/kg	A
2,4,6-Trichlorophenol	0/6		ND	ug/kg	0/8		ND	ug/kg	A
2,4-Dichlorophenol	0/6		ND	ug/kg	0/8		ND	ug/kg	A

0764

E-II-6

4282

TABLE E.II-1
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
2,4-Dimethylphenol	0/6		ND	ug/kg	0/8		ND	ug/kg	A
2,4-Dinitrophenol	0/6		ND	ug/kg	0/8		ND	ug/kg	A
2,4-Dinitrotoluene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
2,6-Dichlorophenol					0/3		ND	ug/kg	A
2,6-Dinitrotoluene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
2-Acetylaminofluorene					0/3		ND	ug/kg	A
2-Chloronaphthalene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
2-Chlorophenol	0/6		ND	ug/kg	0/8		ND	ug/kg	A
2-Methylnaphthalene	2/6	240	250.60812	ug/kg	2/8	140	298.29	ug/kg	D
2-Methylphenol	0/6		ND	ug/kg	0/8		ND	ug/kg	A
2-Naphthylamine					0/3		ND	ug/kg	A
2-Nitroaniline	0/6		ND	ug/kg	0/8		ND	ug/kg	A
2-Nitrophenol	0/6		ND	ug/kg	0/8		ND	ug/kg	A
2-Picoline					0/3		ND	ug/kg	A
3,3'-Dichlorobenzidine	1/6	130	534.52081	ug/kg	0/8		ND	ug/kg	D
3,3'-Dimethylbenzidine					0/3		ND	ug/kg	A
3-Methylcholanthrene					0/3		ND	ug/kg	A
3-Methylphenol					1/3	42	579.70	ug/kg	D
3-Nitroaniline	0/6		ND	ug/kg	0/8		ND	ug/kg	A
4,6-Dinitro-2-methylphenol	0/6		ND	ug/kg	0/8		ND	ug/kg	A
4-Aminobiphenyl					0/3		ND	ug/kg	A
4-Bromophenyl phenyl ether	0/6		ND	ug/kg	0/8		ND	ug/kg	A
4-Chloro-3-methylphenol	0/6		ND	ug/kg	0/8		ND	ug/kg	A
4-Chloroaniline	0/6		ND	ug/kg	0/8		ND	ug/kg	A
4-Chlorophenylphenyl ether	0/6		ND	ug/kg	0/8		ND	ug/kg	A

0765

E-II-7

4287

TABLE E.II-1
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
4-Methylphenol	0/6		ND	ug/kg	0/8		ND	ug/kg	A
4-Nitroaniline	0/6		ND	ug/kg	0/7		ND	ug/kg	A
4-Nitrophenol	0/6		ND	ug/kg	0/8		ND	ug/kg	A
4-Nitroquinoline-1-oxide					0/1		ND	ug/kg	A
5-Nitro-o-toluidine					0/3		ND	ug/kg	A
7,12-Dimethylbenz(a)anthracene					0/3		ND	ug/kg	A
a,a-Dimethylphenethylamine					0/3		ND	ug/kg	A
Acenaphthene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Acenaphthylene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Acetophenone					0/3		ND	ug/kg	A
Aniline					0/3		ND	ug/kg	A
Anthracene	1/6	74	267.41355	ug/kg	0/8		ND	ug/kg	D
Aramite					0/3		ND	ug/kg	A
Benzo(a)anthracene	3/6	180	244.69352	ug/kg	0/8		ND	ug/kg	Retained
Benzo(a)pyrene	1/6	140	257.30299	ug/kg	0/7		ND	ug/kg	Retained
Benzo(b)fluoranthene	5/6	330	307.14881	ug/kg	0/8		ND	ug/kg	Retained
Benzo(g,h,i)perylene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Benzo(k)fluoranthene	1/6	140	257.30299	ug/kg	0/8		ND	ug/kg	Retained
Benzoic acid	0/1		ND	ug/kg	3/8	380	1253.31	ug/kg	B
Benzyl alcohol	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Bis(2-chloroethoxy)methane	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Bis(2-chloroethyl)ether	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Bis(2-chloroisopropyl)ether	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Bis(2-ethylhexyl)phthalate	2/6	1800	1384.8624	ug/kg	4/8	350	354.08	ug/kg	B
Butyl benzyl phthalate	0/6		ND	ug/kg	0/8		ND	ug/kg	A

0766
E-II-8

4282

TABLE E.II-1
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Chrysene	5/6	540	451.28733	ug/kg	0/8		ND	ug/kg	Retained
Di-n-butyl phthalate	0/6		ND	ug/kg	1/8	83	305.05	ug/kg	B
Di-n-octyl phthalate	4/6	830	525.48371	ug/kg	0/8		ND	ug/kg	B
Diallate					0/3		ND	ug/kg	A
Dibenzo(a,h)anthracene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Dibenzofuran	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Diethyl phthalate	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Dimethyl phthalate	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Diphenylamine					0/4		ND	ug/kg	A
Ethyl methanesulfonate					0/3		ND	ug/kg	A
Fluoranthene	6/6	430	338.98172	ug/kg	2/8	1000	531.84	ug/kg	Retained
Fluorene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Hexachlorobenzene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Hexachlorobutadiene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Hexachlorocyclopentadiene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Hexachloroethane	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Hexachlorophene					0/3		ND	ug/kg	A
Indeno(1,2,3-cd)pyrene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Isophorone	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Isosafrole					0/3		ND	ug/kg	A
Methapyrilene					0/1		ND	ug/kg	A
Methyl methanesulfonate					0/4		ND	ug/kg	A
N-nitroso-di-n-propylamine	0/6		ND	ug/kg	0/8		ND	ug/kg	A
N-nitrosodi-n-butylamine					0/3		ND	ug/kg	A
N-nitrosodiethylamine					0/3		ND	ug/kg	A

4787

E-II-9

0767

TABLE E.II-1
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
N-nitrosodimethylamine					0/3		ND	ug/kg	A
N-nitrosodiphenylamine	0/6		ND	ug/kg	0/8		ND	ug/kg	A
N-nitrosomethylethylamine					0/3		ND	ug/kg	A
N-nitrosomorpholine					0/3		ND	ug/kg	A
N-nitrosopiperidine					0/3		ND	ug/kg	A
N-nitrosopyrrolidine					0/3		ND	ug/kg	A
Naphthalene	2/6	67	255.12433	ug/kg	0/8		ND	ug/kg	D
Nitrobenzene	0/6		ND	ug/kg	0/8		ND	ug/kg	A
o,o,o-Triethylphosphorothioate					0/4		ND	ug/kg	A
o-Toluidine					0/2		ND	ug/kg	A
p-Dimethylaminoazobenzene					0/3		ND	ug/kg	A
p-Phenylenediamine					0/3		ND	ug/kg	A
Pentachlorobenzene					0/3		ND	ug/kg	A
Pentachloroethane					0/3		ND	ug/kg	A
Pentachloronitrobenzene					0/3		ND	ug/kg	A
Pentachlorophenol	0/6		ND	ug/kg	0/8		ND	ug/kg	A
Phenacetin					0/3		ND	ug/kg	A
Phenanthrene	6/6	2400	1881.9053	ug/kg	5/8	2100	1139.00	ug/kg	Retained
Phenol	0/6		ND	ug/kg	1/8	420	345.41	ug/kg	D
Pronamide					0/3		ND	ug/kg	A
Pyrene	6/6	360	287.76547	ug/kg	1/8	490	364.54	ug/kg	D
Safrole					0/3		ND	ug/kg	A
Tributyl phosphate					3/3	25000	32646.66	ug/kg	Retained
1,1,1,2-Tetrachloroethane					0/4		ND	ug/kg	A
1,1,1-Trichloroethane	1/5	120	119.528	ug/kg	5/9	120	42.39	ug/kg	D

0768

E-II-10

4282

TABLE E.II-1
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
1,1,2,2-Tetrachloroethane	0/5		ND	ug/kg	0/9		ND	ug/kg	A
1,1,2-Trichloroethane	0/5		ND	ug/kg	0/9		ND	ug/kg	A
1,1-Dichloroethane	0/5		ND	ug/kg	2/9	33	12.29	ug/kg	D
1,1-Dichloroethene	0/5		ND	ug/kg	1/9	16	7.18	ug/kg	D
1,2-Dibromo-3-chloropropane					0/4		ND	ug/kg	A
1,2-Dibromoethane					0/4		ND	ug/kg	A
1,2-Dichloroethane	0/5		ND	ug/kg	0/9		ND	ug/kg	A
1,2-Dichloroethylene					0/9		ND	ug/kg	A
1,2-Dichloropropane	0/5		ND	ug/kg	0/9		ND	ug/kg	A
1,3-Dichloropropene	0/5		ND	ug/kg					A
1,4-Dioxane					2/4	57.7	3641.00	ug/kg	D
2-Butanone	5/5	3800	3207.1044	ug/kg	4/9	29	15.76	ug/kg	B
2-Chloro-1,3-butadiene					0/4		ND	ug/kg	A
2-Chloroethyl vinyl ether	0/5		ND	ug/kg					A
2-Hexanone	0/5		ND	ug/kg	3/9	10	7.34	ug/kg	D
3-Chloropropene					0/4		ND	ug/kg	A
4-Methyl-2-pentanone	0/5		ND	ug/kg	5/9	8	6.00	ug/kg	D
Acetone	1/5	320	331.15943	ug/kg	4/8	170	92.08	ug/kg	B
Acetonitrile					0/4		ND	ug/kg	A
Acrolein					0/4		ND	ug/kg	A
Acrylonitrile					0/2		ND	ug/kg	A
Benzene	0/5		ND	ug/kg	0/9		ND	ug/kg	A
Bromodichloromethane	0/5		ND	ug/kg	0/9		ND	ug/kg	A
Bromoform	0/5		ND	ug/kg	0/9		ND	ug/kg	A
Bromomethane	0/5		ND	ug/kg	0/9		ND	ug/kg	A

TABLE E.II-1
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Carbon disulfide	0/5		ND	ug/kg	0/9		ND	ug/kg	A
Carbon tetrachloride	0/5		ND	ug/kg	1/9	2	3.35	ug/kg	B
Chlorobenzene	0/5		ND	ug/kg	0/9		ND	ug/kg	A
Chloroethane	0/5		ND	ug/kg	0/9		ND	ug/kg	A
Chloroform	3/5	210	170.98206	ug/kg	6/9	600	220.31	ug/kg	B
Chloromethane	0/5		ND	ug/kg	0/9		ND	ug/kg	A
Cis-1,3-dichloropropene				ug/kg	0/9		ND	ug/kg	A
Dibromochloromethane	0/5		ND	ug/kg	0/9		ND	ug/kg	A
Dibromomethane					0/4		ND	ug/kg	A
Dichlorodifluoromethane					1/2	29600	107881.86	ug/kg	Retained
Ethyl cyanide					0/4		ND	ug/kg	A
Ethyl methacrylate					0/4		ND	ug/kg	A
Ethylbenzene	2/5	55	120.27815	ug/kg	4/9	220	80.26	ug/kg	D
Iodomethane					0/4		ND	ug/kg	A
Isobutyl alcohol					0/3		ND	ug/kg	A
Methacrylonitrile					0/4		ND	ug/kg	A
Methyl methacrylate					0/4		ND	ug/kg	A
Methylene chloride	3/5	1000	684.29881	ug/kg	1/9	26	12.55	ug/kg	B
Pyridine					0/3		ND	ug/kg	A
Styrene	0/5		ND	ug/kg	0/9		ND	ug/kg	A
Tetrachloroethene	1/5	120	119.528	ug/kg	6/9	650	252.22	ug/kg	Retained
Toluene	3/5	96	117.88741	ug/kg	6/9	49	18.58	ug/kg	B
Total Xylenes	0/5	ND	ug/kg		8/9	1100	408.47	ug/kg	A
trans-1,2-Dichloroethene	0/5		ND	ug/kg					A
trans-1,3-Dichloropropene					0/9		ND	ug/kg	A

0770

E-II-12

TABLE E.II-1
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
trans-1,4-Dichloro-2-butene					0/3		ND	ug/kg	A
Trichloroethene	0/5		ND	ug/kg	3/9	27	10.89	ug/kg	D
Trichlorofluoromethane					0/4		ND	ug/kg	A
Vinyl Acetate	0/5		ND	ug/kg	0/9		ND	ug/kg	A
Vinyl Chloride	0/5		ND	ug/kg	0/9		ND	ug/kg	A
1,2,3-Trichloropropane					0/4		ND	ug/kg	A
Liquid Limit					5/5	20	12.53	S.U.	F
Plasticity Index					5/5	3	1.88	S.U.	F
Specific Gravity					5/5	3.1515	3.11	S.U.	F

0771

E-II-13

4787

TABLE E.II-2

PIT 2 MATERIAL ANALYTICAL RESULTS

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
1-Methyl pyrene	1/1	220	-	ug/kg					I
3H-Benz(e)indole-2-carboxylic	1/1	2800	-	ug/kg					I
4-Chlorophenyl phenyl ether	0/2		ND	ug/kg					I
4-Methyl-2-hexanone	1/1	3500	-	ug/kg					I
5,5-Dimethyl-2(h)-furanone	1/1	2100	-	ug/kg					I
9H-Fluorene-9-carbonitrile	1/1	500	-	ug/kg					I
Benz(c)phenanthrene	1/1	1100	-	ug/kg					I
Benz(e)acephenanthrylene	1/1	1700	-	ug/kg					I
Benzo(b)naphtho(2,1-d)thiophene	1/1	540	-	ug/kg					I
Benzo(c)phenanthrene	1/1	940	-	ug/kg					I
Benzo(ghi)fluoranthene	1/1	1200	-	ug/kg					I
Benzo(j)fluoranthene	2/2	620	1310.82	ug/kg					I
Hexanedioic acid, dioctyl ester	1/1	7500	-	ug/kg					I
Methyl Pyrene	1/1	1100	-	ug/kg					I
Methyl Triphenylene	1/1	500	-	ug/kg					I
N-nitrosodipropylamine	0/3		ND	ug/kg					A
1,2,3,4,6,7,8-Heptachlorodibenzo-p-					2/4	3.8	3.30	ng/g	Retained
1,2,3,4,6,7,8-Heptachlorodibenzofuran					1/4	1	0.866	ng/g	Retained
1,2,3,4,7,8,9-Heptachlorodibenzofuran					0/4		ND	ng/g	A
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin					0/4		ND	ng/g	A
1,2,3,4,7,8-Hexachlorodibenzofuran					1/4	0.26	0.256	ng/g	Retained
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin					0/4		ND	ng/g	A
1,2,3,6,7,8-Hexachlorodibenzofuran					0/4		ND	ng/g	A
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin					0/4		ND	ng/g	A
1,2,3,7,8,9-Hexachlorodibenzofuran					0/4		ND	ng/g	A

FEMP-01R1.4 DRAFT
 October 12, 1993
 4282

0772

E-II-14

TABLE E.II-2
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
1,2,3,7,8-Pentachlorodibenzo-p-dioxin					0/4		ND	ng/g	A
1,2,3,7,8-Pentachlorodibenzofuran					0/4		ND	ng/g	A
2,3,4,6,7,8-Hexachlorodibenzofuran					0/4		ND	ng/g	A
2,3,4,7,8-Pentachlorodibenzofuran					0/4		ND	ng/g	A
2,3,7,8-TCDD					0/4		ND	ng/g	A
2,3,7,8-TCDF					0/4		ND	ng/g	A
Heptachlorodibenzo-p-dioxin					3/4	8.1	7.05	ng/g	Retained
Heptachlorodibenzofuran					3/4	5.9	5.12	ng/g	Retained
Hexachlorodibenzo-p-dioxin					1/4	0.32	0.367	ng/g	Retained
Hexachlorodibenzofuran					2/4	2.7	2.28	ng/g	Retained
Octachlorodibenzo-p-dioxin					3/4	45.9	40.3	ng/g	Retained
Octachlorodibenzofuran					3/4	4.9	4.30	ng/g	Retained
Pentachlorodibenzo-p-dioxin					0/4		ND	ng/g	A
Pentachlorodibenzofuran					1/4	0.55	0.481	ng/g	Retained
Tetrachlorodibenzo-p-dioxin					0/4		ND	ng/g	A
Tetrachlorodibenzofuran					0/4		ND	ng/g	A
Ammonia					2/4	2.4	2.32	mg/kg	G
Bromide					0/2		ND	mg/kg	A
Chloride					2/2	4898	10,148	mg/kg	C
Fluoride					0/2		ND	mg/kg	A
Nitrate					2/2	9054	21,478	mg/kg	C
Oil and grease					3/3	16000	20,680	mg/kg	F
Phosphate					2/2	1235	4,049	mg/kg	C
Phosphorus					3/3	43703	46,524	mg/kg	C
Sulfate					2/2	739	1,021	mg/kg	C

4782

07773

E-II-15, 1993

TABLE E.II-2
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Sulfide					0/2		ND	mg/kg	A
Total organic carbon					2/2	113712	121,343	mg/kg	F
Total organic nitrogen					2/4	11700	12,157	mg/kg	F
pH					4/4	8.91	8.73	S.U.	F
2,4,5-T					0/2		ND	ug/kg	A
2,4,5-TP (silvex)					0/2		ND	ug/kg	A
2,4-D					0/2		ND	ug/kg	A
Dinoseb					0/5		ND	ug/kg	A
Aluminum	5/5	22400	21707.106	mg/kg	4/4	23100	23,310	mg/kg	H
Antimony	2/5	1.2	0.9952706	mg/kg	4/4	55.4	58.8	mg/kg	Retained
Arsenic	5/5	10	7.5098557	mg/kg	4/4	423	380	mg/kg	Retained
Barium	5/5	208	174.27450	mg/kg	4/4	1920	1,955	mg/kg	Retained
Beryllium	5/5	8.9	6.3982923	mg/kg	4/4	26.9	26.8	mg/kg	Retained
Boron					4/4	238	248	mg/kg	Retained
Cadmium	5/5	9.6	7.9217153	mg/kg	4/4	12.8	13.5	mg/kg	Retained
Calcium	5/5	80100	71127.128	mg/kg	4/4	104000	113,005	mg/kg	C
Chromium	5/5	91	67.383971	mg/kg	4/4	282	294	mg/kg	Retained
Cobalt	5/5	451	294.67519	mg/kg	4/4	1470	1,322	mg/kg	Retained
Copper	5/5	329	222.44171	mg/kg	4/4	1340	1,259	mg/kg	Retained
Cyanide	0/5		ND	mg/kg	4/4	2.9	2.64	mg/kg	Retained
Iron	5/5	24000	24188.090	mg/kg	4/4	39200	36,437	mg/kg	C
Lead	5/5	190	139.92330	mg/kg	4/4	758	848	mg/kg	Retained
Magnesium	5/5	26700	25875.952	mg/kg	4/4	67900	69,415	mg/kg	C
Manganese	5/5	917	846.47514	mg/kg	4/4	2850	2,657	mg/kg	Retained
Mercury	4/5	0.7	0.5813590	mg/kg	4/4	2.6	2.81	mg/kg	Retained

TABLE E.II-2
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Molybdenum					4/4	215	193	mg/kg	Retained
Nickel	5/5	609	403.57251	mg/kg	4/4	1740	1,581	mg/kg	Retained
Potassium	5/5	4320	3519.6538	mg/kg	4/4	10800	10,871	mg/kg	C
Selenium	3/5	10	6.6709825	mg/kg	4/4	131	114	mg/kg	Retained
Silicon					4/4	2640	2,675	mg/kg	H
Silver	3/5	23	17.113082	mg/kg	4/4	42.5	41.0	mg/kg	Retained
Sodium	5/5	2300	1743.6771	mg/kg	4/4	8710	8,099	mg/kg	C
Thallium	0/5		ND	mg/kg	1/4	2.4	2.10	mg/kg	Retained
Tin					0/4		ND	mg/kg	A
Vanadium	5/5	106	82.489986	mg/kg	4/4	594	529	mg/kg	Retained
Zinc	5/5	3250	2070.0181	mg/kg	4/4	488	468	mg/kg	Retained
Azinphosmethyl					0/1		ND	ug/kg	A
Demeton					0/1		ND	ug/kg	A
Diazinon					0/1		ND	ug/kg	A
Dimethoate					0/2		ND	ug/kg	A
Disulfoton					0/2		ND	ug/kg	A
Ethion					0/2		ND	ug/kg	A
Famphur					0/2		ND	ug/kg	A
Malathion					0/1		ND	ug/kg	A
Parathion, ethyl					0/2		ND	ug/kg	A
Parathion, methyl					0/2		ND	ug/kg	A
Phorate					0/2		ND	ug/kg	A
Sulfotepp					0/5		ND	ug/kg	A
Tetraethylpyrophosphate					0/1		ND	ug/kg	A
Thionazin					0/2		ND	ug/kg	A

28237

0775

E-II-17

TABLE E.II-2
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
4,4'-DDD	0/5		ND	ug/kg	0/4		ND	ug/kg	A
4,4'-DDE	0/5		ND	ug/kg	0/4		ND	ug/kg	A
4,4'-DDT	2/5	1400	1042.7948	ug/kg	0/4		ND	ug/kg	Retained
Aldrin	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Alpha-BHC	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Alpha-Chlordane					0/4		ND	ug/kg	A
Aroclor-1016	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Aroclor-1221	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Aroclor-1232	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Aroclor-1242	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Aroclor-1248	1/5	321	1750.3644	ug/kg	2/4	4900	4,322	ug/kg	Retained
Aroclor-1254	1/5	323	3357.1144	ug/kg	0/4		ND	ug/kg	Retained
Aroclor-1260	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Beta-BHC	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Chlordane	0/5		ND	ug/kg					A
Chlorobenzilate					0/2		ND	ug/kg	A
Delta-BHC	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Dieldrin	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Endosulfan I	0/5		ND	ug/kg					A
Endosulfan II	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Endosulfan sulfate	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Endosulfan-I					0/4		ND	ug/kg	A
Endrin	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Endrin ketone	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Gamma-BHC (Lindane)	0/5		ND	ug/kg	0/4		ND	ug/kg	A

0776

E-II-18

4782

TABLE E.II-2
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Gamma-chlordane					0/4		ND	ug/kg	A
Heptachlor	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Heptachlor epoxide	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Isodrin					0/2		ND	ug/kg	A
Kepone					0/2		ND	ug/kg	A
Methoxychlor	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Toxaphene	0/5		ND	ug/kg	0/4		ND	ug/kg	A
1,2,4,5-Tetrachlorobenzene					0/3		ND	ug/kg	A
1,2,4-Trichlorobenzene	0/5		ND	ug/kg	0/7		ND	ug/kg	A
1,2-Dichlorobenzene	0/5		ND	ug/kg	0/7		ND	ug/kg	A
1,3-Dichlorobenzene	0/5		ND	ug/kg	0/7		ND	ug/kg	A
1,3-Dinitrobenzene					0/3		ND	ug/kg	A
1,4-Dichlorobenzene	0/5		ND	ug/kg	0/7		ND	ug/kg	A
1-Naphthylamine					0/3		ND	ug/kg	A
2,3,4,6-Tetrachlorophenol					0/3		ND	ug/kg	A
2,4,5-Trichlorophenol	0/5		ND	ug/kg	0/7		ND	ug/kg	A
2,4,6-Trichlorophenol	0/5		ND	ug/kg	0/7		ND	ug/kg	A
2,4-Dichlorophenol	0/5		ND	ug/kg	0/7		ND	ug/kg	A
2,4-Dimethylphenol	1/5	150	587.69442	ug/kg	0/7		ND	ug/kg	D
2,4-Dinitrophenol	0/5		ND	ug/kg	0/7		ND	ug/kg	A
2,4-Dinitrotoluene	0/5		ND	ug/kg	0/7		ND	ug/kg	A
2,6-Dichlorophenol					0/3		ND	ug/kg	A
2,6-Dinitrotoluene	0/5		ND	ug/kg	0/7		ND	ug/kg	A
2-Acetylaminofluorene					0/1		ND	ug/kg	A
2-Chloronaphthalene	0/5		ND	ug/kg	0/7		ND	ug/kg	A

4289

E-II-19 2000
07/77

TABLE E.II-2
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
2-Chlorophenol	0/5		ND	ug/kg	1/7	220	1,272	ug/kg	D
2-Methylnaphthalene	2/5	7000	4499.3226	ug/kg	3/7	7800	4,976	ug/kg	Retained
2-Methylphenol	0/5		ND	ug/kg	0/7		ND	ug/kg	A
2-Naphthylamine					0/3		ND	ug/kg	A
2-Nitroaniline	0/5		ND	ug/kg	0/7		ND	ug/kg	A
2-Nitrophenol	0/5		ND	ug/kg	0/7		ND	ug/kg	A
2-Picoline					0/3		ND	ug/kg	A
3,3'-Dichlorobenzidine	0/5		ND	ug/kg	0/7		ND	ug/kg	A
3,3'-Dimethylbenzidine					0/1		ND	ug/kg	A
3-Methylcholanthrene					0/1		ND	ug/kg	A
3-Methylphenol					0/3		ND	ug/kg	A
3-Nitroaniline	0/5		ND	ug/kg	0/7		ND	ug/kg	A
4,6-Dinitro-2-methylphenol	0/3		ND	ug/kg	0/7		ND	ug/kg	A
4-Aminobiphenyl					0/3		ND	ug/kg	A
4-Bromophenyl phenyl ether	0/5		ND	ug/kg	0/7		ND	ug/kg	A
4-Chloro-3-methylphenol	0/5		ND	ug/kg	1/7	230	1,272	ug/kg	D
4-Chloroaniline	0/5		ND	ug/kg	0/7		ND	ug/kg	A
4-Chlorophenylphenyl ether	0/3		ND	ug/kg	0/7		ND	ug/kg	A
4-Methylphenol	1/5	350	607.19247	ug/kg	1/7	190	1,278	ug/kg	D
4-Nitroaniline	1/5	4900	4209.7360	ug/kg	0/7		ND	ug/kg	Retained
4-Nitrophenol	0/5		ND	ug/kg	1/7	190	6,147	ug/kg	Retained
4-Nitroquinoline-1-oxide					0/3		ND	ug/kg	A
5-Nitro-o-toluidine					0/3		ND	ug/kg	A
7,12-Dimethylbenz(a)anthracene					0/1		ND	ug/kg	A
A,a-Dimethylphenethylamine					0/1		ND	ug/kg	A

0778

E-II-20

78787

TABLE E.II-2
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Acenaphthene	2/5	1200	875.82029	ug/kg	3/7	31000	20,046	ug/kg	Retained
Acenaphthylene	1/5	43000	27080.475	ug/kg	1/7	110	1,280	ug/kg	Retained
Acetophenone					0/2		ND	ug/kg	A
Aniline					0/3		ND	ug/kg	A
Anthracene	4/5	120000	75572.274	ug/kg	3/7	56000	30,808	ug/kg	Retained
Aramite					0/1		ND	ug/kg	A
Benzo(a)anthracene	5/5	130000	82038.101	ug/kg	3/7	100000	62,237	ug/kg	Retained
Benzo(a)pyrene	4/5	120000	75696.609	ug/kg	3/7	68000	43,659	ug/kg	Retained
Benzo(b)fluoranthene	5/5	10000	7405.4095	ug/kg	3/7	130000	55,627	ug/kg	Retained
Benzo(g,h,i)perylene	3/5	42000	26509.642	ug/kg	3/7	42000	27,330	ug/kg	Retained
Benzo(k)fluoranthene	4/5	75000	47292.673	ug/kg	3/7	44000	25,625	ug/kg	Retained
Benzoic acid	0/3		ND	ug/kg	4/7	850	4,307	ug/kg	B
Benzyl alcohol	0/5		ND	ug/kg	0/7		ND	ug/kg	A
Bis(2-chloroethoxy)methane	0/5		ND	ug/kg	0/7		ND	ug/kg	A
Bis(2-chloroethyl)ether	0/5		ND	ug/kg	0/7		ND	ug/kg	A
Bis(2-chloroisopropyl)ether	0/5		ND	ug/kg	0/7		ND	ug/kg	A
Bis(2-ethylhexyl)phthalate	0/5		ND	ug/kg	1/7	980	1224	ug/kg	B
Butyl benzyl phthalate	0/5		ND	ug/kg	0/7		ND	ug/kg	B
Chrysene	5/6	130000	65931.881	ug/kg	2/7	86000	46,191	ug/kg	Retained
Di-n-butyl phthalate	1/5	96	637.40777	ug/kg	0/7		ND	ug/kg	B
Di-n-octyl phthalate	4/5	570	662.45051	ug/kg	1/7	480	1,274	ug/kg	B
Diallate					0/1		ND	ug/kg	A
Dibenzo(a,h)anthracene	2/5	16000	10203.624	ug/kg	3/7	20000	10,995	ug/kg	Retained
Dibenzofuran	3/5	36000	22722.771	ug/kg	3/7	21000	13,665	ug/kg	Retained
Diethyl phthalate	0/5		ND	ug/kg	1/7	110	1,283	ug/kg	B

4787

E-II-21

0779

TABLE E.II-2
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Dimethyl phthalate	0/5		ND	ug/kg	0/7		ND	ug/kg	B
Diphenylamine					0/3		ND	ug/kg	A
Ethyl methanesulfonate					0/3		ND	ug/kg	A
Fluoranthene	5/5	490000	308915.33	ug/kg	5/7	280000	158,105	ug/kg	Retained
Fluorene	3/5	62000	39137.699	ug/kg	3/7	37000	23,188	ug/kg	Retained
Hexachlorobenzene	0/5		ND	ug/kg	0/7		ND	ug/kg	A
Hexachlorobutadiene	0/5		ND	ug/kg	0/7		ND	ug/kg	A
Hexachlorocyclopentadiene	0/5		ND	ug/kg	0/7		ND	ug/kg	A
Hexachloroethane	0/5		ND	ug/kg	0/7		ND	ug/kg	A
Hexachlorophene					0/1		ND	ug/kg	A
Hexachloropropene					0/2		ND	ug/kg	A
Indeno(1,2,3-cd)pyrene	3/5	46000	29050.446	ug/kg	3/7	37000	23,459	ug/kg	Retained
Isophorone	0/5		ND	ug/kg	0/7		ND	ug/kg	A
Isosafrole					0/3		ND	ug/kg	A
Methyl methanesulfonate					0/3		ND	ug/kg	A
N-nitroso-di-n-propylamine	0/2		ND	ug/kg	0/7		ND	ug/kg	A
N-nitrosodi-n-butylamine					0/3		ND	ug/kg	A
N-nitrosodiethylamine					0/3		ND	ug/kg	A
N-nitrosodimethylamine					0/3		ND	ug/kg	A
N-nitrosodiphenylamine	0/5		ND	ug/kg	1/7	170	1,278	ug/kg	D
N-nitrosomethylethylamine					0/3		ND	ug/kg	A
N-nitrosomorpholine					0/3		ND	ug/kg	A
N-nitrosopiperidine					0/3		ND	ug/kg	A
N-nitrosopyrrolidine					0/3		ND	ug/kg	A
Naphthalene	3/5	16000	10274.064	ug/kg	3/7	23000	14,272	ug/kg	Retained

42821

E-II-22

0780

0780

TABLE E.II-2
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Nitrobenzene	0/5		ND	ug/kg	0/7		ND	ug/kg	A
O,o,o-Triethylphosphorothioate					0/5		ND	ug/kg	A
O-Toluidine					0/2		ND	ug/kg	A
P-Dimethylaminoazobenzene					0/1		ND	ug/kg	A
P-phenylenediamine					0/3		ND	ug/kg	A
Pentachlorobenzene					0/3		ND	ug/kg	A
Pentachloroethane					0/3		ND	ug/kg	A
Pentachloronitrobenzene					0/3		ND	ug/kg	A
Pentachlorophenol	0/5		ND	ug/kg	2/7	1600	5,525	ug/kg	Retained
Phenacetin					0/3		ND	ug/kg	A
Phenanthrene	4/4	18000	15239.869	ug/kg	5/7	280000	155,708	ug/kg	Retained
Phenol	1/5	330	603.90533	ug/kg	2/7	230	1,267	ug/kg	D
Pronamide					0/3		ND	ug/kg	A
Pyrene	5/5	250000	158249.43	ug/kg	5/7	230000	131,554	ug/kg	Retained
Safrole					0/3		ND	ug/kg	A
Tributyl phosphate					4/4	39000	41,746	ug/kg	Retained
1,1,1,2-Tetrachloroethane					0/3		ND	ug/kg	A
1,1,1-Trichloroethane	1/4	150	188.12295	ug/kg	8/11	150	98.9	ug/kg	D
1,1,2,2-Tetrachloroethane	0/4		ND	ug/kg	0/11		ND	ug/kg	A
1,1,2-Trichloroethane	0/4		ND	ug/kg	0/11		ND	ug/kg	A
1,1-Dichloroethane	0/4		ND	ug/kg	7/11	23	10.4	ug/kg	D
1,1-Dichloroethene	0/4		ND	ug/kg	6/11	120	36.7	ug/kg	D
1,2-Dibromo-3-chloropropane					0/3		ND	ug/kg	A
1,2-Dibromoethane					0/3		ND	ug/kg	A
1,2-Dichloroethane	0/4		ND	ug/kg	7/11	20	12.1	ug/kg	D

4287

E-II-23

0781

TABLE E.II-2
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
1,2-Dichloroethylene				ug/kg	0/10		ND	ug/kg	A
1,2-Dichloropropane	0/4		ND	ug/kg	0/11		ND	ug/kg	A
1,3-Dichloropropene	0/4		ND	ug/kg					A
1,4-Dioxane					2/3	654	740	ug/kg	D
2-Butanone	2/2	2700	2965.7	ug/kg	0/7		ND	ug/kg	B
2-Chloro-1,3-butadiene					0/3		ND	ug/kg	A
2-Chloroethyl vinyl ether	0/2		ND	ug/kg					A
2-Hexanone	0/4		ND	ug/kg	0/9		ND	ug/kg	A
3-Chloropropene					0/3		ND	ug/kg	A
4-Methyl-2-pentanone	0/4		ND	ug/kg	0/11		ND	ug/kg	A
Acetone	2/4	540	488.23438	ug/kg	2/7	71	38.3	ug/kg	B
Acetonitrile					0/2		ND	ug/kg	A
Acrolein					0/2		ND	ug/kg	A
Acrylonitrile					0/3		ND	ug/kg	A
Benzene	0/4		ND	ug/kg	1/11	4	8.90	ug/kg	Retained
Bromodichloromethane	0/4		ND	ug/kg	0/11		ND	ug/kg	A
Bromoform	0/4		ND	ug/kg	0/11		ND	ug/kg	A
Bromomethane	0/4		ND	ug/kg	0/11		ND	ug/kg	A
Carbon disulfide	0/4		ND	ug/kg	0/11		ND	ug/kg	B
Carbon tetrachloride	0/4		ND	ug/kg	0/11		ND	ug/kg	B
Chlorobenzene	0/4		ND	ug/kg	0/11		ND	ug/kg	A
Chloroethane	0/4		ND	ug/kg	0/11		ND	ug/kg	A
Chloroform	0/4		ND	ug/kg	7/11	84	32.6	ug/kg	B
Chloromethane	0/4		ND	ug/kg	0/11		ND	ug/kg	A
Cis-1,3-dichloropropene					0/11		ND	ug/kg	A

TABLE E.II-2
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Dibromochloromethane	0/4		ND	ug/kg	0/11		ND	ug/kg	A
Dibromomethane					0/3		ND	ug/kg	A
Dichlorodifluoromethane					0/3		ND	ug/kg	A
Ethyl cyanide					0/3		ND	ug/kg	A
Ethyl methacrylate					0/3		ND	ug/kg	A
Ethylbenzene	1/4	48	196.26397	ug/kg	2/11	26	12.7	ug/kg	D
Iodomethane					0/3		ND	ug/kg	A
Isobutyl alcohol					0/2		ND	ug/kg	A
Methacrylonitrile					0/2		ND	ug/kg	A
Methyl methacrylate					0/3		ND	ug/kg	A
Methylene chloride	2/4	200	262.36830	ug/kg	1/9	66	32.9	ug/kg	B
Pyridine					0/1		ND	ug/kg	A
Styrene	0/4		ND	ug/kg	0/11		ND	ug/kg	A
Tetrachloroethene	0/4		ND	ug/kg	1/11	45	17.0	ug/kg	Retained
Toluene	0/4		ND	ug/kg	0/11		ND	ug/kg	B
Total xylenes	1/4	260	249.31628	ug/kg	1/11	15	11.7	ug/kg	D
Trans-1,2-dichloroethene	0/4		ND	ug/kg					A
Trans-1,3-dichloropropene					0/11		ND	ug/kg	A
Trans-1,4-dichloro-2-butene					0/3		ND	ug/kg	A
Trichloroethene	0/4		ND	ug/kg	1/11	7	8.80	ug/kg	D
Trichlorofluoromethane					0/3		ND	ug/kg	A
Vinyl acetate	0/4		ND	ug/kg	0/11		ND	ug/kg	A
Vinyl chloride	1/4	670	621.66597	ug/kg	6/11	1900	724	ug/kg	Retained
1,2,3-Trichloropropane					0/3		ND	ug/kg	A

283

E-II-25 0783

TABLE E.II-3

PIT 3 MATERIAL ANALYTICAL RESULTS

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-					5/6	1.7	1.12	ng/g	Retained
1,2,3,4,6,7,8-Heptachlorodibenzofuran					3/6	0.21	0.164	ng/g	Retained
1,2,3,4,7,8,9-Heptachlorodibenzofuran					0/6		ND	ng/g	A
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin					0/6		ND	ng/g	A
1,2,3,4,7,8-Hexachlorodibenzofuran					0/6		ND	ng/g	A
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin					1/6	0.048	0.256	ng/g	Retained
1,2,3,6,7,8-Hexachlorodibenzofuran					0/6		ND	ng/g	A
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin					0/6		ND	ng/g	A
1,2,3,7,8,9-Hexachlorodibenzofuran					0/6		ND	ng/g	A
1,2,3,7,8-Pentachlorodibenzo-p-dioxin					0/6		ND	ng/g	A
1,2,3,7,8-Pentachlorodibenzofuran					0/6		ND	ng/g	A
2,3,4,6,7,8-Hexachlorodibenzofuran					0/6		ND	ng/g	A
2,3,4,7,8-Pentachlorodibenzofuran					0/6		ND	ng/g	A
2,3,7,8-TCDD					0/6		ND	ng/g	A
2,3,7,8-TCDF					0/6		ND	ng/g	A
Heptachlorodibenzo-p-dioxin					5/6	3.2	2.10	ng/g	Retained
Heptachlorodibenzofuran					5/6	0.95	0.687	ng/g	Retained
Hexachlorodibenzo-p-dioxin					1/6	0.26	0.180	ng/g	Retained
Hexachlorodibenzofuran					4/6	0.35	0.267	ng/g	Retained
Octachlorodibenzo-p-dioxin					6/6	19.4	12.7	ng/g	Retained
Octachlorodibenzofuran					5/6	1.1	0.745	ng/g	Retained
Pentachlorodibenzo-p-dioxin					0/6		ND	ng/g	A
Pentachlorodibenzofuran					0/6		ND	ng/g	A
Tetrachlorodibenzo-p-dioxin					0/6		ND	ng/g	A
Tetrachlorodibenzofuran					1/6	0.2	0.117	ng/g	Retained

TABLE E.II-3
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Ammonia					0/5		ND	mg/kg	A
Bromide					0/4		ND	mg/kg	A
Chloride					4/4	23700	24,255	mg/kg	C
Fluoride					2/5	2350	1,993	mg/kg	C
Nitrate					4/4	57400	61,087	mg/kg	C
Oil and grease					4/4	1510	1,370	mg/kg	F
Phosphate					0/4		ND	mg/kg	C,A
Phosphorus					6/6	57817	29,940	mg/kg	C,A
Sulfate					4/4	44345	38,184	mg/kg	C,A
Sulfide					1/2	8.6	30.8	mg/kg	C,A
Total organic carbon					3/3	230672	264,557	mg/kg	F
Total organic nitrogen					6/6	8914	7,101	mg/kg	F
pH					6/6	8.32	8.14	S.U.	F
2,4,5-T					0/3		ND	ug/kg	A
2,4,5-TP (silvex)					0/3		ND	ug/kg	A
2,4-D					0/3		ND	ug/kg	A
Dinoseb					0/4		ND	ug/kg	A
Aluminum	7/7	64100	35881.856	mg/kg	6/6	17400	15,086	mg/kg	H
Antimony	2/7	18	10.002143	mg/kg	4/6	63.5	52.5	mg/kg	Retained
Arsenic	7/7	3050	1800.8481	mg/kg	6/6	37200	21,290	mg/kg	Retained
Barium	7/7	14400	8080.1353	mg/kg	6/6	3570	2,537	mg/kg	Retained
Beryllium	7/7	24	14.431561	mg/kg	6/6	10.7	8.64	mg/kg	Retained
Boron					4/6	236	155	mg/kg	Retained
Cadmium	7/7	13	8.4618028	mg/kg	6/6	38.6	25.9	mg/kg	Retained
Calcium	7/7	178000	131484.64	mg/kg	6/6	190000	162,003	mg/kg	C
Chromium	7/7	152	109.67270	mg/kg	6/6	234	186	mg/kg	Retained

787

E-II-27

TABLE E.II-3
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cobalt	7/7	21	17.539084	mg/kg	6/6	50.7	36.0	mg/kg	Retained
Copper	4/7	2330	1673.3387	mg/kg	6/6	2010	1,742	mg/kg	Retained
Cyanide	0/6		ND	mg/kg	4/6	1.7	1.61	mg/kg	Retained
Iron	7/7	26900	21795.323	mg/kg	6/6	25800	22,061	mg/kg	C
Lead	5/7	613	357.96629	mg/kg	6/6	837	670	mg/kg	Retained
Magnesium	7/7	51600	37988.605	mg/kg	6/6	51700	45,513	mg/kg	C
Manganese	7/7	10600	5120.3470	mg/kg	6/6	20200	16,705	mg/kg	Retained
Mercury	5/7	4	1.9978122	mg/kg	5/6	5.1	3.19	mg/kg	Retained
Molybdenum					6/6	284	241	mg/kg	Retained
Nickel	7/7	504	265.76674	mg/kg	6/6	292	206	mg/kg	Retained
Potassium	7/7	3180	2539.6484	mg/kg	6/6	3370	2,548	mg/kg	C
Selenium	5/7	90	49.475178	mg/kg	5/6	6	4.29	mg/kg	Retained
Silicon					4/4	5000	4,701	mg/kg	H
Silver	4/7	8.1	6.6210905	mg/kg	6/6	41.8	37.4	mg/kg	Retained
Sodium	7/7	7640	4772.2083	mg/kg	6/6	10100	9,083	mg/kg	C
Thallium	3/7	12	6.3954889	mg/kg	4/6	4.1	3.15	mg/kg	Retained
Tin					1/5	191	134	mg/kg	Retained
Vanadium	7/7	9700	5202.7236	mg/kg	6/6	2200	1,892	mg/kg	Retained
Zinc	3/7	311	168.46748	mg/kg	6/6	325	211	mg/kg	Retained
Azinphosmethyl					0/3		ND	ug/kg	A
Demeton					0/3		ND	ug/kg	A
Diazinon					0/3		ND	ug/kg	A
Dimethoate					0/3		ND	ug/kg	A
Disulfoton					0/3		ND	ug/kg	A
Ethion					0/3		ND	ug/kg	A
Famphur					0/3		ND	ug/kg	A

4282

E-II-28

0786

6870

TABLE E.II-3
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Malathion					0/3		ND	ug/kg	A
Parathion, ethyl					0/3		ND	ug/kg	A
Parathion, methyl					0/3		ND	ug/kg	A
Phorate					0/3		ND	ug/kg	A
Sulfotepp					0/4		ND	ug/kg	A
Tetraethylpyrophosphate					0/3		ND	ug/kg	A
Thionazin					0/3		ND	ug/kg	A
4,4'-DDD	0/5		ND	ug/kg	0/6		ND	ug/kg	A
4,4'-DDE	0/5		ND	ug/kg	0/6		ND	ug/kg	A
4,4'-DDT	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Aldrin	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Alpha-BHC	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Alpha-Chlordane					0/6		ND	ug/kg	A
Aroclor-1016	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Aroclor-1221	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Aroclor-1232	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Aroclor-1242	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Aroclor-1248	0/5		ND	ug/kg	4/6	4800	2,725	ug/kg	Retained
Aroclor-1254	1/5	140	331.31450	ug/kg	5/6	3400	2,075	ug/kg	Retained
Aroclor-1260	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Beta-BHC	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Chlordane	0/5		ND	ug/kg					A
Chlorobenzilate					0/3		ND	ug/kg	A
Delta-BHC	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Dieldrin	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Endosulfan I	0/5		ND	ug/kg	0/6		ND	ug/kg	A

782

E-II-29

0787

TABLE E.II-3
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Endosulfan II	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Endosulfan sulfate	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Endrin	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Endrin ketone	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Gamma-BHC (Lindane)	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Gamma-Chlordane					0/6		ND	ug/kg	A
Heptachlor	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Heptachlor Epoxide	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Isodrin					0/3		ND	ug/kg	A
Kepone					0/3		ND	ug/kg	A
Methoxychlor	0/5		ND	ug/kg	0/6		ND	ug/kg	A
Toxaphene	0/5		ND	ug/kg	0/6		ND	ug/kg	A
1,2,4,5-Tetrachlorobenzene					0/1		ND	ug/kg	A
1,2,4-Trichlorobenzene	0/7		ND	ug/kg	0/4		ND	ug/kg	A
1,2-Dichlorobenzene	0/7		ND	ug/kg	0/4		ND	ug/kg	A
1,3,5-Trinitrobenzene					0/1		ND	ug/kg	A
1,3-Dichlorobenzene	0/7		ND	ug/kg	0/4		ND	ug/kg	A
1,3-Dinitrobenzene					0/1		ND	ug/kg	A
1,4-Dichlorobenzene	0/7		ND	ug/kg	0/4		ND	ug/kg	A
1,4-Naphthoquinone					0/1		ND	ug/kg	A
1-Naphthylamine					0/1		ND	ug/kg	A
2,3,4,6-Tetrachlorophenol					0/1		ND	ug/kg	A
2,4,5-Trichlorophenol	0/6		ND	ug/kg	0/4		ND	ug/kg	A
2,4,6-Trichlorophenol	0/6		ND	ug/kg	0/4		ND	ug/kg	A
2,4-Dichlorophenol	0/6		ND	ug/kg	0/4		ND	ug/kg	A
2,4-Dimethylphenol	0/7		ND	ug/kg	0/4		ND	ug/kg	A

42821

E-II-30

0788

TABLE E.II-3
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
2,4-Dinitrophenol	0/4		ND	ug/kg	0/4		ND	ug/kg	A
2,4-Dinitrotoluene	0/7		ND	ug/kg	0/4		ND	ug/kg	A
2,6-Dichlorophenol					0/1		ND	ug/kg	A
2,6-Dinitrotoluene	0/7		ND	ug/kg	0/4		ND	ug/kg	A
2-Acetylaminofluorene					0/1		ND	ug/kg	A
2-Chloronaphthalene	0/7		ND	ug/kg	0/4		ND	ug/kg	A
2-Chlorophenol	0/6		ND	ug/kg	0/4		ND	ug/kg	A
2-Methylnaphthalene	0/7		ND	ug/kg	0/4		ND	ug/kg	A
2-Methylphenol	0/6		ND	ug/kg	0/4		ND	ug/kg	A
2-Naphthylamine					0/1		ND	ug/kg	A
2-Nitroaniline	0/7		ND	ug/kg	0/4		ND	ug/kg	A
2-Nitrophenol	0/6		ND	ug/kg	0/4		ND	ug/kg	A
2-Picoline					0/1		ND	ug/kg	A
3,3'-Dichlorobenzidine					0/7		ND	ug/kg	A
3,3'-Dimethylbenzidine					0/1		ND	ug/kg	A
3,3-Dichlorobenzidine	0/7		ND	ug/kg					A
3-Methylcholanthrene					0/1		ND	ug/kg	A
3-Methylphenol					0/1		ND	ug/kg	A
3-Nitroaniline	0/7		ND	ug/kg	0/4		ND	ug/kg	A
4,6-Dinitro-2-methylphenol	1/6	2600	2376.5360	ug/kg	0/4		ND	ug/kg	D
4-Aminobiphenyl				ug/kg	0/1		ND	ug/kg	A
4-Bromophenyl phenyl ether	0/7		ND	ug/kg	0/4		ND	ug/kg	A
4-Chloro-3-methylphenol	0/6		ND	ug/kg	0/4		ND	ug/kg	A
4-Chloroaniline	0/7		ND	ug/kg	0/4		ND	ug/kg	A
4-Chlorophenylphenyl ether	0/7		ND	ug/kg	0/4		ND	ug/kg	A
4-Methylphenol	0/6		ND	ug/kg	0/4		ND	ug/kg	A

4288

E-II-31
0790

TABLE E.II-3
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
4-Nitroaniline	0/7		ND	ug/kg	0/4		ND	ug/kg	A
4-Nitrophenol	0/4		ND	ug/kg	0/4		ND	ug/kg	A
4-Nitroquinoline-1-oxide					0/1		ND	ug/kg	A
5-Nitro-o-toluidine					0/1		ND	ug/kg	A
7,12-Dimethylbenz(a)anthracene					0/1		ND	ug/kg	A
a,a-Dimethylphenethylamine					0/1		ND	ug/kg	A
Acenaphthene	0/5		ND	ug/kg	0/4		ND	ug/kg	A
Acenaphthylene	0/7		ND	ug/kg	1/4	96	571	ug/kg	D
Acetophenone					0/1		ND	ug/kg	A
Aniline					0/1		ND	ug/kg	A
Anthracene	0/7		ND	ug/kg	1/7	130	472	ug/kg	D
Aramite					0/1		ND	ug/kg	A
Benzo(a)anthracene	1/7	60	393.88663	ug/kg	1/7	360	471	ug/kg	Retained
Benzo(a)pyrene	0/7		ND	ug/kg	1/7	280	467	ug/kg	Retained
Benzo(b)fluoranthene	1/7	110	391.46979	ug/kg	1/7	560	510	ug/kg	Retained
Benzo(g,h,i)perylene	0/7		ND	ug/kg	1/7	160	470	ug/kg	Retained
Benzo(k)fluoranthene	0/7		ND	ug/kg	0/7		ND	ug/kg	A
Benzoic acid					2/4	370	2,774	ug/kg	B
Benzyl alcohol	0/7		ND	ug/kg	0/4		ND	ug/kg	A
Bis(2-chloroethoxy)methane	0/7		ND	ug/kg	0/4		ND	ug/kg	A
Bis(2-chloroethyl)ether	0/7		ND	ug/kg	0/4		ND	ug/kg	A
Bis(2-chloroisopropyl)ether	0/7		ND	ug/kg	0/4		ND	ug/kg	A
Bis(2-ethylhexyl)phthalate	6/7	1100	643.49152	ug/kg	7/7	840	581	ug/kg	B
Butyl benzyl phthalate	0/7		ND	ug/kg	0/7		ND	ug/kg	B
Chrysene	1/7	75	393.05555	ug/kg	1/7	370	472	ug/kg	Retained
Di-n-butyl phthalate	3/7	84	352.58917	ug/kg	2/7	310	417	ug/kg	B

TABLE E.II-3
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Di-n-octyl phthalate	0/7		ND	ug/kg	0/7		ND	ug/kg	B
Diallate					0/1		ND	ug/kg	A
Dibenzo(a,h)anthracene	0/7		ND	ug/kg	0/7		ND	ug/kg	A
Dibenzofuran	0/7		ND	ug/kg	0/4		ND	ug/kg	A
Diethyl phthalate	0/7		ND	ug/kg	2/4	4300	3,658	ug/kg	B
Dimethyl phthalate	0/7		ND	ug/kg	0/4		ND	ug/kg	A
Diphenylamine					0/1		ND	ug/kg	A
Ethyl methanesulfonate					0/1		ND	ug/kg	A
Fluoranthene	1/7	230	391.29007	ug/kg	2/7	720	563	ug/kg	D
Fluorene	0/7		ND	ug/kg	0/4		ND	ug/kg	A
Hexachlorobenzene	0/7		ND	ug/kg	0/4		ND	ug/kg	A
Hexachlorobutadiene	0/7		ND	ug/kg	0/4		ND	ug/kg	A
Hexachlorocyclopentadiene	0/7		ND	ug/kg	0/4		ND	ug/kg	A
Hexachloroethane	0/7		ND	ug/kg	0/4		ND	ug/kg	A
Hexachlorophene					0/1		ND	ug/kg	A
Hexachloropropene					0/1		ND	ug/kg	A
Indeno(1,2,3-cd)pyrene	0/7		ND	ug/kg	1/7	130	472	ug/kg	Retained
Isophorone	0/7		ND	ug/kg	3/5	470	460	ug/kg	D
Isosafrole					0/1		ND	ug/kg	A
Methapyrilene					0/1		ND	ug/kg	A
Methyl methanesulfonate					0/1		ND	ug/kg	A
N-nitroso-di-n-propylamine	0/6		ND	ug/kg	2/4	460	507	ug/kg	D
N-nitrosodi-n-butylamine					0/1		ND	ug/kg	A
N-nitrosodiethylamine					0/1		ND	ug/kg	A
N-nitrosodimethylamine					0/1		ND	ug/kg	A
N-nitrosodiphenylamine	0/7		ND	ug/kg	0/4		ND	ug/kg	A

47821

E-II-33
0791

TABLE E.II-3
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
N-nitrosomethylethylamine					0/1		ND	ug/kg	A
N-nitrosomorpholine					0/1		ND	ug/kg	A
N-nitrosopiperidine					0/1		ND	ug/kg	A
N-nitrosopyrrolidine					0/1		ND	ug/kg	A
Naphthalene	0/7		ND	ug/kg	0/4		ND	ug/kg	A
Nitrobenzene	0/7		ND	ug/kg	0/4		ND	ug/kg	A
o,o,o-Triethylphosphorothioate					0/4		ND	ug/kg	A
o-Toluidine					0/1		ND	ug/kg	A
p-Dimethylaminoazobenzene					0/1		ND	ug/kg	A
p-Phenylenediamine					0/1		ND	ug/kg	A
Pentachlorobenzene					0/1		ND	ug/kg	A
Pentachloroethane					0/1		ND	ug/kg	A
Pentachloronitrobenzene					0/1		ND	ug/kg	A
Pentachlorophenol	2/6	1300	1467.6516	ug/kg	5/5	1000	783	ug/kg	Retained
Phenacetin					0/1		ND	ug/kg	A
Phenanthrene	1/7	120	391.11879	ug/kg	2/7	580	523	ug/kg	D
Phenol	0/6		ND	ug/kg	0/4		ND	ug/kg	A
Pronamide					0/1		ND	ug/kg	A
Pyrene	1/7	190	390.24669	ug/kg	2/7	620	532	ug/kg	D
Safrole					0/1		ND	ug/kg	A
Tributyl phosphate					0/1		ND	ug/kg	A
1,1,1,2-Tetrachloroethane					0/2		ND	ug/kg	A
1,1,1-Trichloroethane	0/6		ND	ug/kg	2/10	170	51.8	ug/kg	D
1,1,2,2-Tetrachloroethane	0/6		ND	ug/kg	0/10		ND	ug/kg	A
1,1,2-Trichloro-1,2,2-trifluore	0/1		ND	ug/kg					A
1,1,2-Trichloroethane	0/6		ND	ug/kg	0/10		ND	ug/kg	A

2074

E-II-34

0792

42821

TABLE E.II-3
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
1,1-Dichloroethane	0/6		ND	ug/kg	0/10		ND	ug/kg	A
1,1-Dichloroethene	0/6		ND	ug/kg	0/10		ND	ug/kg	A
1,2-Dibromo-3-chloropropane					0/2		ND	ug/kg	A
1,2-Dibromoethane					0/2		ND	ug/kg	A
1,2-Dichloroethane	0/6		ND	ug/kg	0/10		ND	ug/kg	A
1,2-Dichloroethylene					0/10		ND	ug/kg	A
1,2-Dichloropropane	0/6		ND	ug/kg	0/10		ND	ug/kg	A
1,3-Dichloropropene	0/6		ND	ug/kg					A
2-Butanone	1/1	3600	-	ug/kg	3/6	86	61.8	ug/kg	B
2-Chloro-1,3-butadiene					0/2		ND	ug/kg	A
2-Chloroethyl vinyl ether	0/1		ND	ug/kg					A
2-Hexanone	0/6		ND	ug/kg	4/10	17	13.2	ug/kg	D
3-Chloropropene					0/2		ND	ug/kg	A
4-Methyl-2-pentanone	0/6		ND	ug/kg	4/10	17	12.8	ug/kg	D
Acetone	0/6		ND	ug/kg	3/6	1200	881	ug/kg	B
Acetonitrile					0/1		ND	ug/kg	A
Acrolein					0/1		ND	ug/kg	A
Acrylonitrile					0/1		ND	ug/kg	A
Benzene	0/6		ND	ug/kg	0/10		ND	ug/kg	A
Bromodichloromethane	0/6		ND	ug/kg	0/10		ND	ug/kg	A
Bromoform	0/6		ND	ug/kg	0/10		ND	ug/kg	A
Bromomethane	0/6		ND	ug/kg	0/10		ND	ug/kg	A
Carbon disulfide	0/6		ND	ug/kg	0/10		ND	ug/kg	A
Carbon tetrachloride	0/6		ND	ug/kg	0/10		ND	ug/kg	A
Chlorobenzene	0/6		ND	ug/kg	0/10		ND	ug/kg	A
Chloroethane	0/6		ND	ug/kg	0/10		ND	ug/kg	A

12827

E-II-35

0793

TABLE E.II-3
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Chloroform	0/6		ND	ug/kg	5/10	110	45.0	ug/kg	B
Chloromethane	0/6		ND	ug/kg	0/10		ND	ug/kg	A
Cis-1,3-dichloropropene					0/10		ND	ug/kg	A
Dibromochloromethane	0/6		ND	ug/kg	0/10		ND	ug/kg	A
Dibromomethane					0/2		ND	ug/kg	A
Ethyl cyanide					0/1		ND	ug/kg	A
Ethyl methacrylate					0/2		ND	ug/kg	A
Ethylbenzene	0/6		ND	ug/kg	0/10		ND	ug/kg	A
Iodomethane					0/2		ND	ug/kg	A
Methacrylonitrile					0/2		ND	ug/kg	A
Methyl methacrylate					0/2		ND	ug/kg	A
Methylene chloride	1/1	420	-	ug/kg	2/10	92	47.5	ug/kg	B
Styrene	0/6		ND	ug/kg	0/10		ND	ug/kg	A
Tetrachloroethane	0/1		ND	ug/kg					A
Tetrachloroethene	0/5		ND	ug/kg	5/10	22	10.7	ug/kg	D
Toluene	0/6		ND	ug/kg	1/10	8	6.82	ug/kg	B
Total Xylenes	0/6		ND	ug/kg	0/10		ND	ug/kg	A
Trans-1,2-dichloroethene	0/6		ND	ug/kg					A
Trans-1,3-dichloropropene					0/10		ND	ug/kg	A
Trans-1,4-dichloro-2-butene					0/2		ND	ug/kg	A
Trichloroethene	0/6		ND	ug/kg	1/10	6	6.14	ug/kg	D
Trichlorofluoromethane					1/2	4.12	5.62	ug/kg	D
Vinyl Acetate	0/6		ND	ug/kg	0/10		ND	ug/kg	A
Vinyl Chloride	0/6		ND	ug/kg	0/10		ND	ug/kg	A
1,2,3-Trichloropropane					0/2		ND	ug/kg	A

TABLE E.II-4

PIT 4 MATERIAL ANALYTICAL RESULTS

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
1,2,3,4,7,8,9-Heptachlorodibenzofuran					3 / 6	2.4	1.59	ng/g	Retained
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin					1 / 6	0.06	0.689	ng/g	Retained
1,2,3,4,7,8-Hexachlorodibenzofuran					5 / 6	2.9	1.80	ng/g	Retained
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin					2 / 6	0.16	0.564	ng/g	Retained
1,2,3,6,7,8-Hexachlorodibenzofuran					5 / 6	1.1	0.830	ng/g	Retained
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin					2 / 6	0.22	0.476	ng/g	Retained
1,2,3,7,8,9-Hexachlorodibenzofuran					3 / 6	0.75	1.04	ng/g	Retained
1,2,3,7,8-Pentachlorodibenzo-p-dioxin					0 / 6		ND	ng/g	A
1,2,3,7,8-Pentachlorodibenzofuran					5 / 6	2.1	1.39	ng/g	Retained
2,3,4,6,7,8-Hexachlorodibenzofuran					4 / 6	1.2	0.814	ng/g	Retained
2,3,4,7,8-Pentachlorodibenzofuran					5 / 6	2.7	1.74	ng/g	Retained
2,3,7,8-TCDD					0 / 6		ND	ng/g	A
2,3,7,8-TCDF					5 / 6	9.9	6.97	ng/g	Retained
Heptachlorodibenzo-p-dioxin					5 / 6	4	3.16	ng/g	Retained
Heptachlorodibenzofuran					5 / 6	4.4	3.18	ng/g	Retained
Hexachlorodibenzo-p-dioxin					4 / 6	2.7	1.85	ng/g	Retained
Hexachlorodibenzofuran					5 / 6	8.5	5.39	ng/g	Retained
Octachlorodibenzo-p-dioxin					5 / 6	9	6.52	ng/g	Retained
Octachlorodibenzofuran					4 / 6	4.9	3.66	ng/g	Retained
Pentachlorodibenzo-p-dioxin					0 / 6		ND	ng/g	A
Pentachlorodibenzofuran					5 / 6	15.3	9.42	ng/g	Retained
Tetrachlorodibenzo-p-dioxin					2 / 6	0.47	0.316	ng/g	Retained
Tetrachlorodibenzofuran					6 / 6	34.1	24.1	ng/g	Retained
Ammonia					2 / 3	235	307	mg/kg	G
Bromide					0 / 2		ND	mg/kg	C

TABLE E.II-4
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Chloride					1 / 2	53	193	mg/kg	C
Fluoride					1 / 2	3793	13,870	mg/kg	C
Nitrate					0 / 2		ND	mg/kg	C
Oil and grease					3 / 4	17902	15,108	mg/kg	F
Phosphate					0 / 2		ND	mg/kg	C
Phosphorus					4 / 4	146	133	mg/kg	C
Sulfate					0 / 2		ND	mg/kg	C
Sulfide					1 / 2	29.1	106	mg/kg	C
Total organic carbon					2 / 2	53646	179,994	mg/kg	F
Total organic nitrogen					4 / 4	833.2	759	mg/kg	F
pH					3 / 3	7.27	7.56	S.U.	F
2,4,5-T					0 / 3		ND	ug/kg	A
2,4,5-TP (SILVEX)					0 / 3		ND	ug/kg	A
2,4-D					0 / 3		ND	ug/kg	A
Dinoseb					0 / 6		ND	ug/kg	A
Aluminum	5 / 5	10300	9845.4502	mg/kg	5 / 5	10700	9,514	mg/kg	H
Antimony	1 / 5	0.5	0.3753830	mg/kg	4 / 5	317	222	mg/kg	Retained
Arsenic	1 / 5	4.6	2.9888179	mg/kg	5 / 5	6.5	5.16	mg/kg	Retained
Barium	5 / 5	6670	4583.9777	mg/kg	5 / 5	3720	3,126	mg/kg	Retained
Beryllium	5 / 5	13	8.3535805	mg/kg	3 / 5	50.6	36.7	mg/kg	Retained
Boron					5 / 5	1010	658	mg/kg	Retained
Cadmium	4 / 5	29	18.628380	mg/kg	5 / 5	34.8	24.5	mg/kg	Retained
Calcium	5 / 5	61200	59585.889	mg/kg	5 / 5	32700	25,289	mg/kg	C
Chromium	5 / 5	94	63.687923	mg/kg	5 / 5	1500	1,049	mg/kg	Retained
Cobalt	3 / 5	84	54.487832	mg/kg	4 / 5	183	129	mg/kg	Retained
Copper	5 / 5	188	129.67130	mg/kg	5 / 5	482	352	mg/kg	Retained

TABLE E.II-4
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cyanide	1 / 5	0.7	0.55056	mg/kg	2 / 5	0.24	0.304	mg/kg	Retained
Iron	5 / 5	16100	13112.941	mg/kg	5 / 5	7420	6,016	mg/kg	C
Lead	5 / 5	63	55.333283	mg/kg	5 / 5	63.2	53.6	mg/kg	Retained
Magnesium	5 / 5	24300	23484.693	mg/kg	5 / 5	34000	26,141	mg/kg	C
Manganese	5 / 5	3600	3339.3130	mg/kg	5 / 5	5620	4,747	mg/kg	Retained
Mercury	3 / 5	0.6	0.4871355	mg/kg	3 / 5	0.62	0.454	mg/kg	Retained
Molybdenum					5 / 5	95.6	69.8	mg/kg	Retained
Nickel	5 / 5	50	38.153059	mg/kg	5 / 5	223	167	mg/kg	Retained
Osmium	1 / 4	102	93.797000	mg/kg					I
Potassium	5 / 5	1920	1685.4705	mg/kg	5 / 5	4210	3,957	mg/kg	C
Selenium	0 / 4		ND	mg/kg	1 / 5	0.37	0.316	mg/kg	Retained
Silicon					5 / 5	4080	4,242	mg/kg	H
Silver	4 / 5	444	279.39215	mg/kg	5 / 5	755	531	mg/kg	Retained
Sodium	5 / 5	1240	917.34691	mg/kg	5 / 5	2280	1,863	mg/kg	C
Thallium	0 / 5		ND	mg/kg	0 / 5		ND	mg/kg	A
Tin	4 / 4	87	82.815704	mg/kg	4 / 5	133	114	mg/kg	Retained
Vanadium	4 / 5	235	153.26397	mg/kg	5 / 5	558	394	mg/kg	Retained
Zinc	4 / 5	84	63.397113	mg/kg	5 / 5	200	143	mg/kg	Retained
Azinphosmethyl					0 / 3		ND	ug/kg	A
Demeton					0 / 3		ND	ug/kg	A
Diazinon					0 / 3		ND	ug/kg	A
Dimethoate					0 / 3		ND	ug/kg	A
Disulfoton					0 / 3		ND	ug/kg	A
Ethion					0 / 3		ND	ug/kg	A
Famphur					0 / 3		ND	ug/kg	A
Malathion					0 / 3		ND	ug/kg	A

4287

E-II-39

0797

TABLE E.II-4
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Parathion, ethyl					0 / 3		ND	ug/kg	A
Parathion, methyl					0 / 3		ND	ug/kg	A
Phorate					0 / 3		ND	ug/kg	A
Sulfotepp					0 / 5		ND	ug/kg	A
Tetraethylpyrophosphate					0 / 3		ND	ug/kg	A
Thionazin					0 / 3		ND	ug/kg	A
4,4'-DDD	0 / 4		ND	ug/kg	0 / 4		ND	ug/kg	A
4,4'-DDE	0 / 4		ND	ug/kg	0 / 4		ND	ug/kg	A
4,4'-DDT	0 / 4		ND	ug/kg	0 / 6		ND	ug/kg	A
Aldrin	0 / 4		ND	ug/kg	0 / 4		ND	ug/kg	A
alpha-BHC	0 / 4		ND	ug/kg	0 / 4		ND	ug/kg	A
alpha-Chlordane					0 / 6		ND	ug/kg	A
Aroclor-1016	0 / 4		ND	ug/kg	0 / 6		ND	ug/kg	A
Aroclor-1221	0 / 4		ND	ug/kg	0 / 6		ND	ug/kg	A
Aroclor-1232	0 / 4		ND	ug/kg	0 / 6		ND	ug/kg	A
Aroclor-1242	2 / 4	1034	904.27604	ug/kg	0 / 6		ND	ug/kg	Retained
Aroclor-1248	2 / 4	854	808.18758	ug/kg	4 / 6	7500	5,922	ug/kg	Retained
Aroclor-1254	4 / 4	1008	942.14515	ug/kg	3 / 6	6800	4,190	ug/kg	Retained
Aroclor-1260	0 / 4		ND	ug/kg	0 / 6		ND	ug/kg	A
Beta-BHC	0 / 4		ND	ug/kg	0 / 4		ND	ug/kg	A
Chlordane	0 / 4		ND	ug/kg					A
Chlorobenzilate					0 / 3		ND	ug/kg	A
delta-BHC	0 / 4		ND	ug/kg	0 / 4		ND	ug/kg	A
Dieldrin	0 / 4		ND	ug/kg	0 / 4		ND	ug/kg	A
Endosulfan I	0 / 4		ND	ug/kg					A
Endosulfan II	0 / 4		ND	ug/kg	0 / 4		ND	ug/kg	A

4782

TABLE E.II-4
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Endosulfan sulfate	0 / 4		ND	ug/kg	0 / 4		ND	ug/kg	A
Endrin	0 / 4		ND	ug/kg	0 / 4		ND	ug/kg	A
Endrin ketone	0 / 4		ND	ug/kg	0 / 6		ND	ug/kg	A
gamma-BHC (Lindane)	0 / 4		ND	ug/kg	0 / 4		ND	ug/kg	A
2-Methylgamma-Chlordane					0 / 6		ND	ug/kg	A
Heptachlor	0 / 4		ND	ug/kg	0 / 4		ND	ug/kg	A
Heptachlor epoxide	0 / 4		ND	ug/kg	0 / 4		ND	ug/kg	A
Isodrin					0 / 3		ND	ug/kg	A
Kepone					0 / 3		ND	ug/kg	A
Methoxychlor	0 / 4		ND	ug/kg	0 / 6		ND	ug/kg	A
Toxaphene	0 / 4		ND	ug/kg	0 / 6		ND	ug/kg	A
1,2,4,5-Tetrachlorobenzene					0 / 3		ND	ug/kg	A
1,2,4-Trichlorobenzene	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
1,2-Dichlorobenzene	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
1,3-Dichlorobenzene	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
1,3-Dinitrobenzene					0 / 3		ND	ug/kg	A
1,4-Dichlorobenzene	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
1,4-Naphthoquinone					0 / 2		ND	ug/kg	A
1-Naphthylamine					0 / 3		ND	ug/kg	A
2,3,4,6-Tetrachlorophenol					0 / 3		ND	ug/kg	A
2,4,5-Trichlorophenol	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
2,4,6-Trichlorophenol	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
2,4-Dichlorophenol	0 / 4		ND	ug/kg	1 / 9	230	559	ug/kg	D
2,4-Dimethylphenol	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
2,4-Dinitrophenol	1 / 4	2300	2112.4515	ug/kg	1 / 9	47	2,720	ug/kg	D
2,4-Dinitrotoluene	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A

47827

E-II-41

0799

TABLE E.II-4
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
2,6-Dichlorophenol					0 / 3		ND	ug/kg	A
2,6-Dinitrotoluene	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
2-Acetylaminofluorene					0 / 2		ND	ug/kg	A
2-Chloronaphthalene	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
2-Chlorophenol	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
2-Methylnaphthalene	1 / 4	730	648.58792	ug/kg	2 / 9	480	386	ug/kg	D
2-Methylphenol	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
2-Naphthylamine					0 / 3		ND	ug/kg	A
2-Nitroaniline	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
2-Nitrophenol	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
2-Picoline					0 / 3		ND	ug/kg	A
3,3'-Dichlorobenzidine	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
3,3'-Dimethylbenzidine					0 / 3		ND	ug/kg	A
3-Methylphenol					0 / 3		ND	ug/kg	A
3-Nitroaniline	0 / 4		ND	ug/kg	0 / 7		ND	ug/kg	A
4,6-Dinitro-2-methylphenol	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
4-Aminobiphenyl					0 / 3		ND	ug/kg	A
4-Bromophenyl phenyl ether	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
4-Chloro-3-methylphenol	0 / 4		ND	ug/kg	2 / 9	77	560	ug/kg	D
4-Chloroaniline	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
4-Chlorophenylphenyl ether	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
4-Methylphenol	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
4-Nitroaniline	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
4-Nitrophenol	1 / 4	2300	2112.4515	ug/kg	0 / 9		ND	ug/kg	Retained
4-Nitroquinoline-1-oxide					0 / 3		ND	ug/kg	A
5-Nitro-o-toluidine					0 / 3		ND	ug/kg	A

4787

TABLE E.II-4
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Acenaphthene	2 / 4	1200	1041.0898	ug/kg	2 / 9	1900	904	ug/kg	Retained
Acenaphthylene	1 / 4	170	238.44142	ug/kg	0 / 9		ND	ug/kg	D
Acetophenone					0 / 3		ND	ug/kg	A
Aniline					0 / 3		ND	ug/kg	A
Anthracene	3 / 4	2500	2158.0684	ug/kg	2 / 9	2700	1,177	ug/kg	Retained
Benzo(a)anthracene	4 / 4	4100	3526.7521	ug/kg	2 / 9	4700	1,999	ug/kg	Retained
Benzo(a)pyrene	3 / 4	4500	3836.5955	ug/kg	2 / 9	2900	1,305	ug/kg	Retained
Benzo(b)fluoranthene	3 / 4	3800	3244.2352	ug/kg	2 / 9	5200	2,360	ug/kg	Retained
Benzo(g,h,i)perylene	2 / 4	170	242.15767	ug/kg	1 / 9	990	691	ug/kg	Retained
Benzo(k)fluoranthene	3 / 4	3700	3168.6509	ug/kg	0 / 9		ND	ug/kg	Retained
Benzoic acid					6 / 9	580	1,217	ug/kg	B
Benzyl alcohol	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
Bis(2-chloroethoxy)methane	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
Bis(2-chloroethyl)ether	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
Bis(2-chloroisopropyl)ether	1 / 4	420	389.23637	ug/kg	0 / 9		ND	ug/kg	D
Bis(2-ethylhexyl)phthalate	3 / 4	270	276.49049	ug/kg	6 / 9	2700	1264	ug/kg	B
Butyl benzyl phthalate	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
Chrysene	4 / 4	4500	3862.2771	ug/kg	2 / 9	3300	1,579	ug/kg	Retained
Di-n-butylphthalate	3 / 4	490	450.43909	ug/kg	2 / 9	150	550	ug/kg	B
Di-n-octyl phthalate	2 / 4	190	230.37709	ug/kg	6 / 9	1000	696	ug/kg	B
Dibenzo(a,h)anthracene	1 / 4	65	272.93337	ug/kg	0 / 9		ND	ug/kg	D
Dibenzofuran	3 / 4	1400	1202.6207	ug/kg	2 / 9	1200	638	ug/kg	Retained
Diethyl phthalate	0 / 4		ND	ug/kg	1 / 9	89	551	ug/kg	B
Dimethyl phthalate	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	B
Diphenylamine					0 / 3		ND	ug/kg	A
Ethyl methanesulfonate					0 / 3		ND	ug/kg	A

TABLE E.II-4
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Fluoranthene	4 / 4	9900	8572.6361	ug/kg	2 / 9	11000	4,211	ug/kg	Retained
Fluorene	3 / 4	2200	1884.1361	ug/kg	2 / 9	2000	951	ug/kg	Retained
Hexachlorobenzene	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
Hexachlorobutadiene	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
Hexachlorocyclopentadiene	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
Hexachloroethane	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
Indeno(1,2,3-cd)pyrene	3 / 4	180	224.02009	ug/kg	1 / 9	990	691	ug/kg	Retained
Isophorone	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
Isosafrole					0 / 3		ND	ug/kg	A
Methyl methanesulfonate					0 / 3		ND	ug/kg	A
N-nitroso-di-n-propylamine	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
N-nitrosodi-n-butylamine					0 / 3		ND	ug/kg	A
N-nitrosodiethylamine					0 / 3		ND	ug/kg	A
N-nitrosodimethylamine					0 / 3		ND	ug/kg	A
N-nitrosodiphenylamine	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
N-nitrosomethylethylamine					0 / 3		ND	ug/kg	A
N-nitrosomorpholine					0 / 3		ND	ug/kg	A
N-nitrosopiperidine					0 / 3		ND	ug/kg	A
N-nitrosopyrrolidine					0 / 3		ND	ug/kg	A
Naphthalene	3 / 4	1100	949.79712	ug/kg	2 / 9	740	450	ug/kg	Retained
Nitrobenzene	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
o,o,o-Triethylphosphorothioate					0 / 5		ND	ug/kg	A
o-Toluidine					0 / 1		ND	ug/kg	A
p-Phenylenediamine					0 / 3		ND	ug/kg	A
Pentachlorobenzene					0 / 3		ND	ug/kg	A
Pentachloroethane					0 / 3		ND	ug/kg	A

4282

TABLE E.II-4
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Pentachloronitrobenzene					0 / 3		ND	ug/kg	A
Pentachlorophenol	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
Phenacetin					0 / 3		ND	ug/kg	A
Phenanthrene	3 / 4	9400	8127.2837	ug/kg	2 / 9	12000	4,751	ug/kg	Retained
Phenol	0 / 4		ND	ug/kg	0 / 9		ND	ug/kg	A
Pronamide					0 / 3		ND	ug/kg	A
Pyrene	4 / 4	6600	5705.8415	ug/kg	2 / 9	9000	3,475	ug/kg	Retained
Safrole					0 / 3		ND	ug/kg	A
Tributyl phosphate					2 / 2	72000	135,768	ug/kg	Retained
1,1,1,2-Tetrachloroethane					0 / 3		ND	ug/kg	A
1,1,1-Trichloroethane	1 / 4	120	167.52825	ug/kg	6 / 11	140	48.3	ug/kg	D
1,1,2,2-Tetrachloroethane	0 / 4		ND	ug/kg	0 / 11		ND	ug/kg	A
1,1,2-Trichloroethane	0 / 4		ND	ug/kg	0 / 11		ND	ug/kg	A
1,1-Dichloroethane	0 / 4		ND	ug/kg	6 / 11	330	91.7	ug/kg	D
1,1-Dichloroethene	0 / 4		ND	ug/kg	3 / 11	11	4.87	ug/kg	D
1,2-Dibromo-3-chloropropane					0 / 2		ND	ug/kg	A
1,2-Dibromoethane					0 / 2		ND	ug/kg	A
1,2-Dichloroethane	0 / 4		ND	ug/kg	2 / 11	6	3.82	ug/kg	D
1,2-Dichloroethene					3 / 11	110	34.8	ug/kg	D
1,2-Dichloropropane	0 / 3		ND	ug/kg	0 / 11		ND	ug/kg	A
1,2-Dichloropropene	0 / 1		ND	ug/kg					A
1,3-Dichloropropene	0 / 4		ND	ug/kg					A
1,4-Dioxane					0 / 2		ND	ug/kg	A
2-Butanone	1 / 1	100	-	ug/kg	4 / 9	59	25.9	ug/kg	B
2-Chloro-1,3-butadiene					0 / 2		ND	ug/kg	A
2-Chloroethyl vinyl ether	0 / 1		ND	ug/kg					A

TABLE E.II-4
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
2-Hexanone	0 / 4		ND	ug/kg	4 / 11	29	12.8	ug/kg	D
3-Chloropropene					1 / 2	3	14.0	ug/kg	D
4-Methyl-2-pentanone	0 / 4		ND	ug/kg	5 / 11	83	26.3	ug/kg	D
Acetone	1 / 4	350	364.14015	ug/kg	1 / 6	17	25.6	ug/kg	B
Acetonitrile					0 / 2		ND	ug/kg	A
Acrolein					0 / 2		ND	ug/kg	A
Acrylonitrile					0 / 2		ND	ug/kg	A
Benzene	0 / 4		ND	ug/kg	1 / 11	14	5.83	ug/kg	D
Bromodichloromethane	0 / 4		ND	ug/kg	0 / 11		ND	ug/kg	A
Bromoform	0 / 4		ND	ug/kg	0 / 11		ND	ug/kg	A
Bromomethane	0 / 4		ND	ug/kg	0 / 11		ND	ug/kg	A
Carbon disulfide	0 / 4		ND	ug/kg	1 / 11	3	3.27	ug/kg	B
Carbon tetrachloride	0 / 4		ND	ug/kg	1 / 11	2	3.20	ug/kg	B
Chlorobenzene	0 / 4		ND	ug/kg	0 / 11		ND	ug/kg	A
Chloroethane	0 / 3		ND	ug/kg	1 / 11	35	13.4	ug/kg	D
Chloroform	4 / 4	1300	1150.9269	ug/kg	6 / 11	630	238	ug/kg	B
Chloromethane	0 / 4		ND	ug/kg	0 / 11		ND	ug/kg	A
Cis-1,3-dichloropropene					0 / 11		ND	ug/kg	A
Dibromochloromethane	0 / 4		ND	ug/kg	0 / 11		ND	ug/kg	A
Dibromomethane					0 / 3		ND	ug/kg	A
Dichlorodifluoromethane					0 / 1		ND	ug/kg	A
Ethyl cyanide					0 / 2		ND	ug/kg	A
Ethyl methacrylate					0 / 3		ND	ug/kg	A
Ethylbenzene	0 / 4		ND	ug/kg	3 / 11	28	9.85	ug/kg	D
Iodomethane					0 / 3		ND	ug/kg	A
Isobutyl alcohol					1 / 2	17	394	ug/kg	D

TABLE E.II-4
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Methacrylonitrile					0 / 2		ND	ug/kg	A
Methyl methacrylate					0 / 3		ND	ug/kg	A
Methylene chloride	3 / 4	2200	1943.0698	ug/kg	3 / 11	230	89.6	ug/kg	B
Styrene	0 / 4		ND	ug/kg	1 / 11	3	3.24	ug/kg	D
Tetrachloroethene	2 / 4	30000	25194.533	ug/kg	6 / 10	240	82.5	ug/kg	Retained
Toluene	2 / 4	67	166.38029	ug/kg	4 / 11	33	13.2	ug/kg	B
Total xylenes	0 / 4		ND	ug/kg	5 / 11	230	68.3	ug/kg	D
Trans-1,2-dichloroethene	1 / 4	60	186.01260	ug/kg					D
Trans-1,3-dichloropropene					0 / 11		ND	ug/kg	D A
Trans-1,4-dichloro-2-butene					0 / 3		ND	ug/kg	D A
Trichloroethene	1 / 4	300	276.98677	ug/kg	7 / 11	210	115	ug/kg	D
Trichlorofluoromethane					1 / 2	2	20.3	ug/kg	D
Vinyl acetate	0 / 4		ND	ug/kg	0 / 11		ND	ug/kg	A
Vinyl chloride	0 / 4		ND	ug/kg	2 / 11	14	8.90	ug/kg	D
1,2,3-Trichloropropane					0 / 3		ND	ug/kg	A

E-II-47 0805

1282

TABLE E.II-5

PIT 5 MATERIAL ANALYTICAL RESULTS

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Ammonia, as nitrogen					9/9	2410	1,407	mg/kg	G
Bromide					0/9		ND	mg/kg	A
Chloride					6/9	1380	846	mg/kg	C
Cyanide					0/9		ND	mg/kg	A
Nitrate/nitrite					9/9	53800	32,850	mg/kg	C
Specific gravity					2/2	1.377	1.77	S.U.	F
Sulfate					3/3	6790	7,751	mg/kg	C
Total Kjeldahl nitrogen					9/9	1940	1,461	mg/kg	F
Total organic carbon					9/9	35000	26,684	mg/kg	F
Total organic nitrogen					9/9	626	430	mg/kg	F
Total phosphorus					9/9	1097	871	mg/kg	C
pH					9/9	10	9.26	S.U.	F
Aluminum	5/5	12500	11452.737	mg/kg	9/9	11900	10,023	mg/kg	H
Antimony	4/5	64	51.655153	mg/kg	9/9	88.1	47.5	mg/kg	Retained
Arsenic	4/5	2800	2146.7776	mg/kg	7/9	715	542	mg/kg	Retained
Barium	5/5	36900	30230.219	mg/kg	9/9	18100	13,179	mg/kg	Retained
Beryllium	5/5	18	14.839082	mg/kg	9/9	22.4	14.2	mg/kg	Retained
Cadmium	4/5	17	11.626793	mg/kg	9/9	4.7	3.32	mg/kg	Retained
Calcium	5/5	206000	224921.12	mg/kg	9/9	250000	210,795	mg/kg	C
Chromium	5/5	141	115.74442	mg/kg	9/9	98	78.9	mg/kg	Retained
Cobalt	4/5	44	35.452060	mg/kg	9/9	17.1	12.1	mg/kg	Retained
Copper	4/5	18200	11810.138	mg/kg	9/9	6450	4,105	mg/kg	Retained
Cyanide	1/3	0.5	0.9575994	mg/kg					Retained
Iron	5/5	17900	17716.716	mg/kg	9/9	20700	14,762	mg/kg	C
Lead	4/5	168	173.65664	mg/kg	9/9	134	105	mg/kg	Retained

TABLE E.II-5
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Magnesium	5/5	63200	59055.018	mg/kg	9/9	43000	37,790	mg/kg	C
Manganese	5/5	3300	3051.4584	mg/kg	9/9	486	466	mg/kg	Retained
Mercury	5/5	1.8	1.5874023	mg/kg	9/9	1.5	1.04	mg/kg	Retained
Molybdenum					9/9	1350	666	mg/kg	Retained
Nickel	5/5	202	150.00487	mg/kg	9/9	178	119	mg/kg	Retained
Osmium	0/1		ND	mg/kg					A
Potassium	4/5	1490	1329.8103	mg/kg	9/9	2160	1,424	mg/kg	C
Selenium	4/5	18	13.75372	mg/kg	0/9		ND	mg/kg	Retained
Silver	3/5	9.4	7.8103037	mg/kg	5/9	22.2	14.1	mg/kg	Retained
Sodium	5/5	9980	8748.1046	mg/kg	9/9	16300	9,826	mg/kg	C
Thallium	4/5	11	9.9375905	mg/kg	4/9	52	34.5	mg/kg	Retained
Tin	1/1	30	-	mg/kg	9/9	92.8	48.0	mg/kg	Retained
Vanadium	5/5	5380	4919.8171	mg/kg	9/9	4530	2,761	mg/kg	Retained
Zinc	3/5	180	166.22248	mg/kg	9/9	278	206	mg/kg	Retained
4,4-DDD	0/6		ND	ug/kg					A
4,4-DDE	0/6		ND	ug/kg					A
4,4-DDT	0/6		ND	ug/kg					A
Aldrin	0/6		ND	ug/kg					A
Alpha-BHC	0/6		ND	ug/kg					A
Aroclor 1016	0/6		ND	ug/kg					A
Aroclor 1221	0/6		ND	ug/kg					A
Aroclor 1232	0/6		ND	ug/kg					A
Aroclor 1242	0/6		ND	ug/kg					A
Aroclor 1248	2/6	550	1080.6495	ug/kg					Retained
Aroclor 1254	2/6	750	2005.9047	ug/kg					Retained
Aroclor 1260	0/6		ND	ug/kg					A

4787

E-II-49

0807

TABLE E.II-5
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Beta-BHC	0/6		ND	ug/kg					A
Chlordane	0/6		ND	ug/kg					A
Delta-BHC	0/6		ND	ug/kg					A
Dieldrin	0/6		ND	ug/kg					A
Endosulfan I	0/6		ND	ug/kg					A
Endosulfan II	0/6		ND	ug/kg					A
Endosulfan sulfate	0/6		ND	ug/kg					A
Endrin	0/6		ND	ug/kg					A
Endrin ketone	0/6		ND	ug/kg					A
Gamma-BHC (Lindane)	0/6		ND	ug/kg					A
Heptachlor	0/6		ND	ug/kg					A
Heptachlor epoxide	0/6		ND	ug/kg					A
Methoxychlor	0/6		ND	ug/kg					A
Toxaphene	0/6		ND	ug/kg					A
1,2,4-Trichlorobenzene	0/6		ND	ug/kg					A
1,2-Dichlorobenzene	0/6		ND	ug/kg					A
1,3-Dichlorobenzene	0/6		ND	ug/kg					A
1,4-Dichlorobenzene	0/6		ND	ug/kg					A
2,4,5-Trichlorophenol	0/6		ND	ug/kg					A
2,4,6-Trichlorophenol	0/6		ND	ug/kg					A
2,4-Dichlorophenol	0/6		ND	ug/kg					A
2,4-Dimethylphenol	0/6		ND	ug/kg					A
2,4-Dinitrophenol	0/6		ND	ug/kg					A
2,4-Dinitrotoluene	0/6		ND	ug/kg					A
2,6-Dinitrotoluene	0/6		ND	ug/kg					A
2-Chloronaphthalene	0/6		ND	ug/kg					A

TABLE E.II-5
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
2-Chlorophenol	0/6		ND	ug/kg					A
2-Methylnaphthalene	0/6		ND	ug/kg					A
2-Methylphenol	0/6		ND	ug/kg					A
2-Nitroaniline	0/6		ND	ug/kg					A
2-Nitrophenol	0/6		ND	ug/kg					A
3,3-Dichlorobenzidine	0/6		ND	ug/kg					A
3-Nitroaniline	0/6		ND	ug/kg					A
4,6-Dinitro-2-methylphenol	0/6		ND	ug/kg					A
4-Bromophenyl phenyl ether	0/6		ND	ug/kg					A
4-Chloro-3-methylphenol	0/6		ND	ug/kg					A
4-Chloroaniline	0/6		ND	ug/kg					A
4-Chlorophenol phenyl ether	0/6		ND	ug/kg					A
4-Methylphenol	0/6		ND	ug/kg					A
4-Nitroaniline	0/6		ND	ug/kg					A
4-Nitrophenol	0/6		ND	ug/kg					A
Acenaphthene	0/6		ND	ug/kg					A
Acenaphthylene	0/6		ND	ug/kg					A
Anthracene	0/6		ND	ug/kg					A
Benzo(a)anthracene	0/6		ND	ug/kg					A
Benzo(a)pyrene	0/6		ND	ug/kg					A
Benzo(b)fluoranthene	0/6		ND	ug/kg					A
Benzo(g,h,i)perylene	0/6		ND	ug/kg					A
Benzo(k)fluoranthene	0/6		ND	ug/kg					A
Benzoic acid	0/3		ND	ug/kg					A
Benzyl alcohol	0/6		ND	ug/kg					A
Bis(2-chloroethoxy)methane	0/6		ND	ug/kg					A

TABLE E.II-5
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Bis(2-chloroethyl)ether	0/6		ND	ug/kg					A
Bis(2-chloroisopropyl)ether	0/6		ND	ug/kg					A
Bis(2-ethylhexyl)phthalate	4/6	2300	1405.8436	ug/kg					B
Bis(chloromethyl)ether	0/4		ND	ug/kg					A
Butyl benzyl phthalate	0/6		ND	ug/kg					A
C-10 unk hydrocarbon	1/1	2100	-	ug/kg					I
Chrysene	0/6		ND	ug/kg					A
Di-n-butylphthalate	1/6	56	605.02908	ug/kg					B
Di-n-octylphthalate	0/6		ND	ug/kg					A
Dibenzo(a,h)anthracene	0/6		ND	ug/kg					A
Dibenzofuran	0/6		ND	ug/kg					A
Diethyl phthalate	0/6		ND	ug/kg					A
Dimethyl phthalate	0/7		ND	ug/kg					A
Fluoranthene	0/6		ND	ug/kg					A
Fluorene	0/6		ND	ug/kg					A
Hexachlorobenzene	0/6		ND	ug/kg					A
Hexachlorobutadiene	0/6		ND	ug/kg					A
Hexachlorocyclopentadiene	0/6		ND	ug/kg					A
Hexachloroethane	0/6		ND	ug/kg					A
Indeno(1,2,3-cd)pyrene	0/6		ND	ug/kg					A
Isophorone	0/6		ND	ug/kg					A
N-nitroso-di-n-propylamine	0/6		ND	ug/kg					A
N-nitrosodiphenylamine	0/6		ND	ug/kg					A
Naphthalene	0/6		ND	ug/kg					A
Nitrobenzene	0/6		ND	ug/kg					A
Pentachlorophenol	0/6		ND	ug/kg					A

TABLE E.II-5
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Phenanthrene	0/6		ND	ug/kg					A
Phenol	1/6	200	615.50255	ug/kg					D
Pyrene	0/6		ND	ug/kg					A
1,1,1-Trichloroethane	0/6		ND	ug/kg					A
1,1,2,2-Tetrachloroethane	0/6		ND	ug/kg					A
1,1,2-Trichloro-1,2,2-trifluore	0/2		ND	ug/kg					A
1,1,2-Trichloroethane	0/6		ND	ug/kg					A
1,1-Dichloroethane	1/6	650	429.04163	ug/kg					D
1,1-Dichloroethene	0/6		ND	ug/kg					A
1,2-Dichloroethane	0/6		ND	ug/kg					A
1,2-Dichloropropane	0/6		ND	ug/kg					A
1,2-Dichloropropylene	0/1		ND	ug/kg					A
1,3-Dichloropropene	0/6		ND	ug/kg					A
1,3-Dichloropropylene	0/3		ND	ug/kg					A
2-chloroethyl vinyl ether	0/4		ND	ug/kg					A
2-hexanone	0/6		ND	ug/kg					A
4-methyl-2-pentanone	0/6		ND	ug/kg					A
Acetone	3/6	6300	3850.6444	ug/kg					B
Acrylonitrile	0/4		ND	ug/kg					A
Benzene	0/6		ND	ug/kg					A
Bromodichloromethane	0/6		ND	ug/kg					A
Bromoform	0/6		ND	ug/kg					A
Bromomethane	1/6	680	652.83385	ug/kg					D
Carbon disulfide	0/6		ND	ug/kg					A
Carbon tetrachloride	0/6		ND	ug/kg					A
Chlorobenzene	0/6		ND	ug/kg					A

4282

E-II-53

0811

TABLE E.II-5
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Chloroethane	0/6		ND	ug/kg					A
Chloroform	0/6		ND	ug/kg					A
Chloromethane	0/4		ND	ug/kg					A
Cis-1,2-dichloroethene	0/4		ND	ug/kg					A
Dibromochloromethane	0/6		ND	ug/kg					A
Dichlorodifluoromethane	0/4		ND	ug/kg					A
Ethylbenzene	0/6		ND	ug/kg					A
Methylene chloride	4/6	410	369.53780	ug/kg					B
Styrene	0/6		ND	ug/kg					A
Tetrachloroethene	0/6		ND	ug/kg					A
Toluene	0/6		ND	ug/kg					A
Total xylenes	0/6		ND	ug/kg					A
Trans-1,2-dichloroethene	0/6		ND	ug/kg					A
Trichloroethene	0/6		ND	ug/kg					A
Vinyl acetate	0/6		ND	ug/kg					A
Vinyl chloride	0/6		ND	ug/kg					A

E-II-54

0812

4287

TABLE E.II-6

PIT 6 ANALYTICAL RESULTS

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Ammonia, as nitrogen					8/8	141	83.8	mg/kg	G
Bromide					1/8	366	193	mg/kg	C
Carbamic acid, monoammonium sa	1/1	19	-	mg/kg					I
Carbon dioxide (acn)	2/2	16	18.657	mg/kg					I
Chloride					4/8	2250	1,609	mg/kg	C
Nitrate/nitrite					3/8	52.4	29.9	mg/kg	C
Oil & grease					2/8	46	37.8	mg/kg	F
Specific gravity					7/7	3.017	2.24	S.U.	F
Sulfate					3/8	1610	1,093	mg/kg	C
Total Kjeldahl nitrogen					8/8	859	748	mg/kg	F
Total organic carbon					8/8	35000	21,924	mg/kg	F
Total organic nitrogen					7/7	801	673	mg/kg	F
Total phosphorus					8/8	3850	2,635	mg/kg	C
pH					7/7	13	12.2	S.U.	F
Aluminum	1/1	4730	-	mg/kg	9/9	19800	16,017	mg/kg	H
Antimony	0/1		ND	mg/kg	0/9		ND	mg/kg	A
Arsenic	1/1	7.6	-	mg/kg	9/9	76.7	54.9	mg/kg	Retained
Barium	1/1	95	-	mg/kg	9/9	71.7	58.6	mg/kg	Retained
Beryllium	1/1	5.7	-	mg/kg	9/9	2.1	1.42	mg/kg	Retained
Cadmium	1/1	5.7	-	mg/kg	1/9	1.3	2.65	mg/kg	Retained
Calcium	1/1	22200	-	mg/kg	9/9	157000	109,694	mg/kg	C
Chromium	1/1	30	-	mg/kg	3/9	7	22.7	mg/kg	Retained
Cobalt	1/1	26	-	mg/kg	5/9	4.6	5.79	mg/kg	Retained
Copper	1/1	222	-	mg/kg	3/9	10.8	15.5	mg/kg	Retained

4787

E-II-55

0813

TABLE E.II-6
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cyanide	0/1		ND	mg/kg	0/8		ND	mg/kg	A
Iron	1/1	2750	-	mg/kg	9/9	14800	11,858	mg/kg	C
Lead	1/1	60	-	mg/kg	9/9	113	79.6	mg/kg	Retained
Magnesium	1/1	32100	-	mg/kg	9/9	41900	29,056	mg/kg	C
Manganese	1/1	35	-	mg/kg	9/9	312	221	mg/kg	Retained
Mercury	0/1		ND	mg/kg	0/9		ND	mg/kg	A
Molybdenum					0/9		ND	mg/kg	A
Nickel	1/1	51	-	mg/kg	9/9	22.7	18.9	mg/kg	Retained
Potassium	1/1	913	-	mg/kg	9/9	6390	4,719	mg/kg	C
Selenium	0/1		ND	mg/kg	0/9		ND	mg/kg	A
Silver	1/1	158	-	mg/kg	7/9	9.2	6.19	mg/kg	Retained
Sodium	1/1	600	-	mg/kg	9/9	586	464	mg/kg	C
Thallium	0/1		ND	mg/kg	6/9	108	71.0	mg/kg	Retained
Tin					7/9	21.5	13.8	mg/kg	Retained
Vanadium	1/1	100	-	mg/kg	0/9		ND	mg/kg	Retained
Zinc	1/1	48	-	mg/kg	9/9	61	44.7	mg/kg	Retained
4,4-DDD	0/1		ND	ug/kg					A
4,4-DDE	0/1		ND	ug/kg					A
4,4-DDT	0/1		ND	ug/kg					A
Aldrin	0/1		ND	ug/kg					A
Alpha-BHC	0/1		ND	ug/kg					A
Aroclor 1016	0/1		ND	ug/kg					A
Aroclor 1221	0/1		ND	ug/kg					A
Aroclor 1232	0/1		ND	ug/kg					A
Aroclor 1242	0/1		ND	ug/kg					A

TABLE E.II-6
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Aroclor 1248	0/1		ND	ug/kg					A
Aroclor 1254	1/1	81	-	ug/kg					Retained
Aroclor 1260	0/1		ND	ug/kg					A
Beta-BHC	0/1		ND	ug/kg					A
Chlordane	0/1		ND	ug/kg					A
Delta-BHC	0/1		ND	ug/kg					A
Dieldrin	0/1		ND	ug/kg					A
Endosulfan I	0/1		ND	ug/kg					A
Endosulfan II	0/1		ND	ug/kg					A
Endosulfan sulfate	0/1		ND	ug/kg					A
Endrin	0/1		ND	ug/kg					A
Endrin ketone	0/1		ND	ug/kg					A
Gamma-BHC (Lindane)	0/1		ND	ug/kg					A
Heptachlor	0/1		ND	ug/kg					A
Heptachlor epoxide	0/1		ND	ug/kg					A
Methoxychlor	0/1		ND	ug/kg					A
Toxaphene	0/1		ND	ug/kg					A
1,2,4-Trichlorobenzene	0/1		ND	ug/kg					A
1,2-Dichlorobenzene	0/1		ND	ug/kg					A
1,3-Dichlorobenzene	0/1		ND	ug/kg					A
1,4-Dichlorobenzene	0/1		ND	ug/kg					A
2,4,5-Trichlorophenol	0/1		ND	ug/kg					A
2,4,6-Trichlorophenol	0/1		ND	ug/kg					A
2,4-Dichlorophenol	0/1		ND	ug/kg					A
2,4-Dimethylphenol	0/1		ND	ug/kg					A

E-II-57

0815

282

TABLE E.II-6
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				nnReason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
2,4-Dinitrophenol	0/1		ND	ug/kg					A
2,4-Dinitrotoluene	0/1		ND	ug/kg					A
2,6-Dinitrotoluene	0/1		ND	ug/kg					A
2-Chloronaphthalene	0/1		ND	ug/kg					A
2-Chlorophenol	0/1		ND	ug/kg					A
2-Methylphenol	0/1		ND	ug/kg					A
2-Nitroaniline	0/1		ND	ug/kg					A
2-Nitrophenol	0/1		ND	ug/kg					A
3,3-Dichlorobenzidine	0/1		ND	ug/kg					A
3-Nitroaniline	0/1		ND	ug/kg					A
4,6-Dinitro-2-methylphenol	0/1		ND	ug/kg					A
4-Bromophenyl phenyl ether	0/1		ND	ug/kg					A
4-Chloroaniline	0/1		ND	ug/kg					A
4-Chlorophenol phenyl ether	0/1		ND	ug/kg					A
4-Methylphenol	0/1		ND	ug/kg					A
4-Nitroaniline	0/1		ND	ug/kg					A
4-Nitrophenol	0/1		ND	ug/kg					A
Acenaphthene	0/1		ND	ug/kg					A
Acenaphthylene	0/1		ND	ug/kg					A
Anthracene	0/1		ND	ug/kg					A
Benzo(a)anthracene	0/1		ND	ug/kg					A
Benzo(a)pyrene	0/1		ND	ug/kg					A
Benzo(b)fluoranthene	0/1		ND	ug/kg					A
Benzo(g,h,i)perylene	0/1		ND	ug/kg					A
Benzo(k)fluoranthene	0/1		ND	ug/kg					A

E-II-58

0816

12827

TABLE E.II-6
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				nnReason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Benzyl alcohol	0/1		ND	ug/kg					A
Bis(2-chloroethoxy)methane	0/1		ND	ug/kg					A
Bis(2-chloroethyl)ether	0/1		ND	ug/kg					A
Bis(2-chloroisopropyl)ether	0/1		ND	ug/kg					A
Bis(2-ethylhexyl)phthalate	1/1	410	-	ug/kg					B
Butyl benzyl phthalate	0/1		ND	ug/kg					A
Chrysene	0/1		ND	ug/kg					A
Di-n-butylphthalate	0/1		ND	ug/kg					A
Di-n-octylphthalate	0/1		ND	ug/kg					A
Dibenzo(a,h)anthracene	0/1		ND	ug/kg					A
Dibenzofuran	0/1		ND	ug/kg					A
Diethyl phthalate	0/1		ND	ug/kg					A
Dimethyl phthalate	0/1		ND	ug/kg					A
Fluoranthene	0/1		ND	ug/kg					A
Fluorene	0/1		ND	ug/kg					A
Hexachlorobenzene	0/1		ND	ug/kg					A
Hexachlorobutadiene	0/1		ND	ug/kg					A
Hexachloroethane	0/1		ND	ug/kg					A
Indeno(1,2,3-cd)pyrene	0/1		ND	ug/kg					A
Isophorone	0/1		ND	ug/kg					A
N-nitroso-di-n-propylamine	0/1		ND	ug/kg					A
N-nitrosodiphenylamine	0/1		ND	ug/kg					A
Naphthalene	0/1		ND	ug/kg					A
Nitrobenzene	0/1		ND	ug/kg					A
Pentachlorophenol	0/1		ND	ug/kg					A

TABLE E.II-6
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				nnReason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Phenanthrene	0/1		ND	ug/kg					A
Phenol	0/1		ND	ug/kg					A
1,1,1-Trichloroethane	0/4		ND	ug/kg					A
1,1,2,2-Tetrachloroethane	0/4		ND	ug/kg					A
1,1,2-Trichloroethane	0/4		ND	ug/kg					A
1,1-Dichloroethane	0/4		ND	ug/kg					A
1,1-Dichloroethene	0/4		ND	ug/kg					A
1,2-Dichloroethane	0/4		ND	ug/kg					A
1,2-Dichloroethene	0/3		ND	ug/kg					A
1,2-Dichloropropane	0/4		ND	ug/kg					A
1,3-Dichloropropene	0/4		ND	ug/kg					A
2-Butanone	1/4	530	926.20984	ug/kg					B
2-Chloroethyl vinyl ether	0/1		ND	ug/kg					A
2-Hexanone	0/4		ND	ug/kg					A
4-Methyl-2-pentanone	0/1		ND	ug/kg					A
Acetone	1/4	3200	2816.3125	ug/kg					B
Benzene	0/4		ND	ug/kg					A
Bromodichloromethane	0/4		ND	ug/kg					A
Bromoform	0/4		ND	ug/kg					A
Bromomethane	0/4		ND	ug/kg					A
Butanoic acid, methyl ester	2/2	6	8.657	ug/kg					D
Carbon disulfide	0/4		ND	ug/kg					A
Carbon tetrachloride	0/4		ND	ug/kg					A
Chlorobenzene	0/4		ND	ug/kg					A
Chloroethane	0/4		ND	ug/kg					A

TABLE E.II-6
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
2-Chloronaphthalene	0/1		ND	ug/kg					A
2-Chlorophenol	0/1		ND	ug/kg					A
2-Methylphenol	0/1		ND	ug/kg					A
2-Nitroaniline	0/1		ND	ug/kg					A
2-Nitrophenol	0/1		ND	ug/kg					A
3,3-Dichlorobenzidine	0/1		ND	ug/kg					A
3-Nitroaniline	0/1		ND	ug/kg					A
4,6-Dinitro-2-methylphenol	0/1		ND	ug/kg					A
4-Bromophenyl phenyl ether	0/1		ND	ug/kg					A
4-Chloroaniline	0/1		ND	ug/kg					A
4-Chlorophenol phenyl ether	0/1		ND	ug/kg					A
4-Methylphenol	0/1		ND	ug/kg					A
4-Nitroaniline	0/1		ND	ug/kg					A
4-Nitrophenol	0/1		ND	ug/kg					A
Acenaphthene	0/1		ND	ug/kg					A
Acenaphthylene	0/1		ND	ug/kg					A
Anthracene	0/1		ND	ug/kg					A
Benzo(a)anthracene	0/1		ND	ug/kg					A
Benzo(a)pyrene	0/1		ND	ug/kg					A
Benzo(b)fluoranthene	0/1		ND	ug/kg					A
Benzo(g,h,i)perylene	0/1		ND	ug/kg					A
Benzo(k)fluoranthene	0/1		ND	ug/kg					A
Benzyl alcohol	0/1		ND	ug/kg					A
Bis(2-chloroethoxy)methane	0/1		ND	ug/kg					A
Bis(2-chloroethyl)ether	0/1		ND	ug/kg					A

TR-FER/OU1 RI/DF.1229EIL 6/09-23:93/10:24am

Legend for this table is presented on the first page of this appendix.

4285

FEMP-01R1-4 DRAFT
October 12, 1993

E-II-61

0819

TABLE E.II-6
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				nnReason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Bis(2-chloroisopropyl)ether	0/1		ND	ug/kg					A
Bis(2-ethylhexyl)phthalate	1/1	410	-	ug/kg					B
Butyl benzyl phthalate	0/1		ND	ug/kg					A
Chrysene	0/1		ND	ug/kg					A
Di-n-butylphthalate	0/1		ND	ug/kg					A
Di-n-octylphthalate	0/1		ND	ug/kg					A
Dibenzo(a,h)anthracene	0/1		ND	ug/kg					A
Dibenzofuran	0/1		ND	ug/kg					A
Diethyl phthalate	0/1		ND	ug/kg					A
Dimethyl phthalate	0/1		ND	ug/kg					A
Fluoranthene	0/1		ND	ug/kg					A
Fluorene	0/1		ND	ug/kg					A
Hexachlorobenzene	0/1		ND	ug/kg					A
Hexachlorobutadiene	0/1		ND	ug/kg					A
Hexachloroethane	0/1		ND	ug/kg					A
Indeno(1,2,3-cd)pyrene	0/1		ND	ug/kg					A
Isophorone	0/1		ND	ug/kg					A
N-nitroso-di-n-propylamine	0/1		ND	ug/kg					A
N-nitrosodiphenylamine	0/1		ND	ug/kg					A
Naphthalene	0/1		ND	ug/kg					A
Nitrobenzene	0/1		ND	ug/kg					A
Pentachlorophenol	0/1		ND	ug/kg					A
Phenanthrene	0/1		ND	ug/kg					A
Phenol	0/1		ND	ug/kg					A
1,1,1-Trichloroethane	0/1		ND	ug/kg					A

E-II-62

0820

42821

TABLE E.II-6
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				nnReason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
1,1,2,2-Tetrachloroethane	0/4		ND	ug/kg					A
1,1,2-Trichloroethane	0/4		ND	ug/kg					A
1,1-Dichloroethane	0/4		ND	ug/kg					A
1,1-Dichloroethene	0/4		ND	ug/kg					A
1,2-Dichloroethane	0/4		ND	ug/kg					A
1,2-Dichloroethene	0/3		ND	ug/kg					A
1,2-Dichloropropane	0/4		ND	ug/kg					A
1,3-Dichloropropene	0/4		ND	ug/kg					A
2-Butanone	1/4	530	926.20984	ug/kg					B
2-Chloroethyl vinyl ether	0/1		ND	ug/kg					A
2-Hexanone	0/4		ND	ug/kg					A
4-Methyl-2-pentanone	0/1		ND	ug/kg					A
Acetone	1/4	3200	2816.3125	ug/kg					B
Benzene	0/4		ND	ug/kg					A
Bromodichloromethane	0/4		ND	ug/kg					A
Bromoform	0/4		ND	ug/kg					A
Bromomethane	0/4		ND	ug/kg					A
Butanoic acid, methyl ester	2/2	6	8.657	ug/kg					D
Carbon disulfide	0/4		ND	ug/kg					A
Carbon tetrachloride	0/4		ND	ug/kg					A
Chlorobenzene	0/4		ND	ug/kg					A
Chloroethane	0/4		ND	ug/kg					A
Choroform	0/4		ND	ug/kg					A
Chloromethane	0/4		ND	ug/kg					A
Dibromochloromethane	0/4		ND	ug/kg					A

TABLE E.II-6
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Ethylbenzene	0/4		ND	ug/kg					A
Methylene chloride	1/3	78000	101786.55	ug/kg					B
Styrene	0/4		ND	ug/kg					A
Chloroform	0/4		ND	ug/kg					A
Chloromethane	0/4		ND	ug/kg					A
Dibromochloromethane	0/4		ND	ug/kg					A
Ethylbenzene	0/4		ND	ug/kg					A
Methylene chloride	1/3	78000	101786.65	ug/kg					B
Styrene	0/4		ND	ug/kg					A
Tetrachloroethene	4/4	29000	31066.419	ug/kg					Retained
Toluene	0/4		ND	ug/kg					A
Total xylene	0/4		ND	ug/kg					A
Trans-1,2-dichloroethene	0/1		ND	ug/kg					A
Trichloroethene	1/4	170	477.18010	ug/kg					D
Vinyl acetate	0/4		ND	ug/kg					A
Vinyl chloride	0/4		ND	ug/kg					A

E-II-64

0822

4787

TABLE E.II-7

BURN PIT MATERIAL ANALYTICAL RESULT

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNIT S	FREQ	MAX DET	UCL (95%)	UNIT S	
1,2,3,4,6,7,8-Heptachlorodibenzo-p-					2 / 4	0.52	0.556	ng/g	Retained
1,2,3,4,6,7,8-Heptachlorodibenzofur					0 / 4		ND	ng/g	A
1,2,3,4,7,8,9-Heptachlorodibenzofur					0 / 4		ND	ng/g	A
1,2,3,4,7,8-Hexachlorodibenzo-p-dio					0 / 4		ND	ng/g	A
1,2,3,4,7,8-Hexachlorodibenzofuran					0 / 4		ND	ng/g	A
1,2,3,6,7,8-Hexachlorodibenzo-p-dio					0 / 4		ND	ng/g	A
1,2,3,6,7,8-Hexachlorodibenzofuran					0 / 4		ND	ng/g	A
1,2,3,7,8,9-Hexachlorodibenzo-p-dio					0 / 4		ND	ng/g	A
1,2,3,7,8,9-Hexachlorodibenzofuran					0 / 4		ND	ng/g	A
1,2,3,7,8-Pentachlorodibenzo-p-diox					0 / 4		ND	ng/g	A
1,2,3,7,8-Pentachlorodibenzofuran					0 / 4		ND	ng/g	A
2,3,4,6,7,8-Hexachlorodibenzofuran					0 / 4		ND	ng/g	A
2,3,4,7,8-Pentachlorodibenzofuran					0 / 4		ND	ng/g	A
2,3,7,8-TCDD					0 / 4		ND	ng/g	A
2,3,7,8-TCDF					0 / 4		ND	ng/g	A
Heptachlorodibenzo-p-dioxin					2 / 4	0.98	1.08	ng/g	Retained
Heptachlorodibenzofuran					0 / 4		ND	ng/g	A
Hexachlorodibenzo-p-dioxin					0 / 4		ND	ng/g	A
Hexachlorodibenzofuran					0 / 4		ND	ng/g	A
Octachlorodibenzo-p-dioxin					2 / 4	4	4.50	ng/g	Retained
Octachlorodibenzofuran					1 / 4	0.13	0.191	ng/g	Retained
Pentachlorodibenzo-p-dioxin					0 / 4		ND	ng/g	A
Pentachlorodibenzofuran					0 / 4		ND	ng/g	A

TABLE E.II-7
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNIT S	FREQ	MAX DET	UCL (95%)	UNIT S	
Tetrachlorodibenzo-p-dioxin					0 / 3		ND	ng/g	A
Tetrachlorodibenzofuran					0 / 3		ND	ng/g	A
Ammonia					0 / 2		ND	mg/kg	A
Bromide					0 / 1		ND	mg/kg	A
Chloride					1 / 1	192		mg/kg	C
Fluoride					1 / 1	49.1		mg/kg	C
Nitrate					0 / 1		ND	mg/kg	A
Phosphorus					2 / 2	783	2,295	mg/kg	C
Sulfate					1 / 1	172		mg/kg	C
Sulfide					1 / 2	59.2	216	mg/kg	C
Total organic carbon					1 / 1	152000		mg/kg	F
Total organic nitrogen					2 / 2	642	1,123	mg/kg	F
pH					1 / 1	8.53		S.U.	F
2,4,5-T					0 / 2		ND	ug/kg	A
2,4,5-TP (SILVEX)					0 / 2		ND	ug/kg	A
2,4-D					0 / 2		ND	ug/kg	A
Dinoseb					0 / 3		ND	ug/kg	A
Aluminum	7 / 7	11900	8878.2616	mg/kg	4 / 4	8550	8,162	mg/kg	H
Antimony	1 / 7	0.6	0.6635527	mg/kg	2 / 4	17.8	18.0	mg/kg	Retained
Arsenic	5 / 7	21	11.807753	mg/kg	4 / 4	39.2	34.7	mg/kg	Retained
Barium	5 / 7	7100	3045.9527	mg/kg	4 / 4	299	327	mg/kg	Retained
Beryllium	5 / 7	16	7.1364137	mg/kg	4 / 4	1.9	2.01	mg/kg	Retained
Boron					2 / 3	48.2	61.3	mg/kg	Retained

47827

E-II-66

0824

TABLE E.II-7
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNIT S	FREQ	MAX DET	UCL (95%)	UNIT S	
Cadmium	7 / 7	35	15.376977	mg/kg	4 / 4	5.4	5.61	mg/kg	Retained
Calcium	7 / 7	116000	69714.460	mg/kg	4 / 4	88900	89,688	mg/kg	C
Chromium	7 / 7	88	43.388008	mg/kg	4 / 4	91.2	92.9	mg/kg	Retained
Cobalt	6 / 7	104	48.423565	mg/kg	4 / 4	111	98.9	mg/kg	Retained
Copper	4 / 7	166	80.309988	mg/kg	4 / 4	259	281	mg/kg	Retained
Cyanide	0 / 7		ND	mg/kg	2 / 4	0.21	0.199	mg/kg	Retained
Iron	7 / 7	17400	13299.854	mg/kg	4 / 4	31200	31,721	mg/kg	C
Lead	5 / 7	53	32.411985	mg/kg	4 / 4	279	310	mg/kg	Retained
Magnesium	7 / 7	57100	31429.575	mg/kg	4 / 4	25700	28,110	mg/kg	C
Manganese	7 / 7	1720	859.01444	mg/kg	4 / 4	962	944	mg/kg	Retained
Mercury	2 / 7	0.2	0.1202071	mg/kg	3 / 4	1.2	1.12	mg/kg	Retained
Molybdenum					4 / 4	24.8	24.9	mg/kg	Retained
Nickel	6 / 7	60	31.460506	mg/kg	4 / 4	206	187	mg/kg	Retained
Potassium	7 / 7	1450	1084.8737	mg/kg	4 / 4	1410	1,435	mg/kg	C
Selenium	1 / 6	0.5	0.3470669	mg/kg	4 / 4	2	1.91	mg/kg	Retained
Silicon					3 / 3	1350	1,613	mg/kg	H
Silver	2 / 6	506	255.26659	mg/kg	4 / 4	21.6	23.5	mg/kg	Retained
Sodium	6 / 7	1270	950.76810	mg/kg	4 / 4	812	780	mg/kg	C
Thallium	3 / 7	0.5	0.4085855	mg/kg	0 / 4		ND	mg/kg	Retained
Tin					0 / 2		ND	mg/kg	A
Vanadium	4 / 7	290	129.48647	mg/kg	4 / 4	43.3	43.6	mg/kg	Retained
Zinc	7 / 7	75	57.783095	mg/kg	4 / 4	505	523	mg/kg	Retained
Azinphosmethyl					0 / 2		ND	ug/kg	A

TABLE E.II-7
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNIT S	FREQ	MAX DET	UCL (95%)	UNIT S	
Demeton					0 / 2		ND	ug/kg	A
Diazinon					0 / 2		ND	ug/kg	A
Dimethoate					0 / 2		ND	ug/kg	A
Disulfoton					0 / 2		ND	ug/kg	A
Ethion					0 / 2		ND	ug/kg	A
Famphur					0 / 2		ND	ug/kg	A
Malathion					0 / 2		ND	ug/kg	A
Parathion, ethyl					0 / 2		ND	ug/kg	A
Parathion, methyl					0 / 2		ND	ug/kg	A
Phorate					0 / 2		ND	ug/kg	A
Sulfotepp					0 / 3		ND	ug/kg	A
Tetraethylpyrophosphate					0 / 2		ND	ug/kg	A
Thionazin					0 / 2		ND	ug/kg	A
4,4'-DDD	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
4,4'-DDE	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
4,4'-DDT	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
Aldrin	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
alpha-BHC	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
alpha-chlordane					0 / 4		ND	ug/kg	A
Aroclor-1016	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
Aroclor-1221	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
Aroclor-1232	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
Aroclor-1242	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A

TABLE E.II-7
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNIT S	FREQ	MAX DET	UCL (95%)	UNIT S	
Aroclor-1248	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
Aroclor-1254	5 / 7	2700	1555.7320	ug/kg	3 / 4	7700	6,688	ug/kg	Retained
Aroclor-1260	0 / 7		ND	ug/kg	0 / 3		ND	ug/kg	A
Beta-BHC	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
Chlordane	0 / 7		ND	ug/kg					A
Chlorobenzilate					0 / 1		ND	ug/kg	A
Delta-BHC	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
Dieldrin	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
Endosulfan I	0 / 7		ND	ug/kg					A
Endosulfan II	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
Endosulfan sulfate	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
Endosulfan-I					0 / 4		ND	ug/kg	A
Endrin	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
Endrin ketone	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
Gamma-BHC (Lindane)					0 / 4		ND	ug/kg	A
Gamma-BHC(Lindane)	0 / 7		ND	ug/kg					A
Gamma-chlordane					0 / 4		ND	ug/kg	A
Heptachlor	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
Heptachlor epoxide	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
Isodrin					0 / 1		ND	ug/kg	A
Kepone					0 / 1		ND	ug/kg	A
Methoxychlor	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A
Toxaphene	0 / 7		ND	ug/kg	0 / 4		ND	ug/kg	A

TABLE E.II-7
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNIT S	FREQ	MAX DET	UCL (95%)	UNIT S	
1,2,4,5-Tetrachlorobenzene					0 / 1		ND	ug/kg	A
1,2,4-Trichlorobenzene	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
1,2-Dichlorobenzene	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
1,3-Dichlorobenzene	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
1,3-Dinitrobenzene					0 / 1		ND	ug/kg	A
1,4-Dichlorobenzene	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
1,4-Naphthoquinone					0 / 1		ND	ug/kg	A
1-Naphthylamine					0 / 1		ND	ug/kg	A
2,3,4,6-Tetrachlorophenol					0 / 1		ND	ug/kg	A
2,4,5-Trichlorophenol	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
2,4,6-Trichlorophenol	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
2,4-Dichlorophenol	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
2,4-Dimethylphenol	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
2,4-Dinitrophenol	0 / 4		ND	ug/kg	0 / 5		ND	ug/kg	A
2,4-Dinitrotoluene	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
2,6-Dichlorophenol					0 / 1		ND	ug/kg	A
2,6-Dinitrotoluene	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
2-Acetylaminofluorene					0 / 1		ND	ug/kg	A
2-Chloronaphthalene	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
2-Chlorophenol	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
2-Methylnaphthalene	1 / 7	50	259.56297	ug/kg	2 / 5	820	641	ug/kg	D
2-Methylphenol	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
2-Naphthylamine					0 / 1		ND	ug/kg	A

E-II-70

0828

4282

TABLE E.II-7
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNIT S	FREQ	MAX DET	UCL (95%)	UNIT S	
2-Nitroaniline	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
2-Nitrophenol	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
2-Picoline					0 / 1		ND	ug/kg	A
3,3'-Dichlorobenzidine					0 / 5		ND	ug/kg	A
3,3'-Dimethylbenzidine					0 / 1		ND	ug/kg	A
3,3-Dichlorobenzidine	0 / 7		ND	ug/kg					A
3-Methylcholanthrene					0 / 1		ND	ug/kg	A
3-Methylphenol					0 / 1		ND	ug/kg	A
3-Nitroaniline	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
4,6-Dinitro-2-methylphenol	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
4-Aminobiphenyl					0 / 1		ND	ug/kg	A
4-Bromophenyl phenyl ether	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
4-Chloro-3-methylphenol	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
4-Chloroaniline	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
4-Chlorophenol phenyl ether	0 / 6		ND	ug/kg					A
4-Chlorophenyl-phenylether	0 / 1		ND	ug/kg					A
4-Chlorophenyl-phenyl ether					0 / 5		ND	ug/kg	A
4-Methylphenol	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
4-Nitroaniline	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
4-Nitrophenol	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
4-Nitroquinoline-1-oxide					0 / 1		ND	ug/kg	A
5-Nitro-o-toluidine					0 / 1		ND	ug/kg	A
7,12-Dimethylbenz(a)anthracene					0 / 1		ND	ug/kg	A

4282

E-II-71
0829

TABLE E.II-7
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNIT S	FREQ	MAX DET	UCL (95%)	UNIT S	
A,a-Dimethylphenethylamine					0 / 1		ND	ug/kg	A
Acenaphthene	0 / 6		ND	ug/kg	1 / 5	1100	810	ug/kg	Retained
Acenaphthylene	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
Acetophenone					0 / 1		ND	ug/kg	A
Aniline					0 / 1		ND	ug/kg	A
Anthracene	0 / 7		ND	ug/kg	1 / 5	3100	2,053	ug/kg	Retained
Aramite					0 / 1		ND	ug/kg	A
Benzo(a)anthracene	4 / 7	170	209.16987	ug/kg	2 / 5	6300	4,029	ug/kg	Retained
Benzo(a)pyrene	1 / 7	160	245.57381	ug/kg	2 / 5	3900	2,529	ug/kg	Retained
Benzo(b)fluoranthene	4 / 7	170	210.39366	ug/kg	1 / 5	9600	6,122	ug/kg	Retained
Benzo(g,h,i)perylene	1 / 7	85	256.20635	ug/kg	2 / 5	2900	1,898	ug/kg	Retained
Benzo(k)fluoranthene	1 / 7	200	241.54293	ug/kg	1 / 5	340	1,663	ug/kg	Retained
Benzoic acid	0 / 3		ND	ug/kg	0 / 5		ND	ug/kg	A
Benzyl alcohol	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
Bis(2-chloroethoxy)methane	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
Bis(2-chloroethyl)ether	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
Bis(2-chloroisopropyl)ether	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
Bis(2-ethylhexyl)phthalate	5 / 7	2000	647.87651	ug/kg	3/5	9700	6151	ug/mg	B
Butyl benzyl phthalate	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	B
Chrysene	3 / 7	83	221.02751	ug/kg	2 / 5	7000	4,468	ug/kg	Retained
Di-n-butyl phthalate	4 / 7	210	240.83902	ug/kg	0 / 5		ND	ug/kg	B
Di-n-octyl phthalate	4 / 7	130	198.23001	ug/kg	0 / 5		ND	ug/kg	B
Diallate					0 / 1		ND	ug/kg	A

TABLE E.II-7
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNIT S	FREQ	MAX DET	UCL (95%)	UNIT S	
Dibenzo(a,h)anthracene	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
Dibenzofuran	0 / 7		ND	ug/kg	1 / 5	900	689	ug/kg	Retained
Diethyl phthalate	0 / 6		ND	ug/kg	1 / 5	80	1,669	ug/kg	B
Dimethyl phthalate	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
Diphenylamine					0 / 1		ND	ug/kg	A
Ethyl methanesulfonate					0 / 1		ND	ug/kg	A
Fluoranthene	3 / 7	210	242.71449	ug/kg	2 / 5	16000	10,115	ug/kg	Retained
Fluorene	0 / 7		ND	ug/kg	2 / 5	1700	1,172	ug/kg	Retained
Hexachlorobenzene	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
Hexachlorobutadiene	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
Hexachlorocyclopentadiene	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
Hexachloroethane	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
Hexachlorophene					0 / 1		ND	ug/kg	A
Hexachloropropene					0 / 1		ND	ug/kg	A
Indeno(1,2,3-cd)pyrene	1 / 6	78	257.36749	ug/kg	2 / 5	2200	1,457	ug/kg	Retained
Isophorone	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
Isosafrole					0 / 1		ND	ug/kg	A
Methyl methanesulfonate					0 / 1		ND	ug/kg	A
N-nitroso-di-n-phenylamine	0 / 1		ND	ug/kg					A
N-nitroso-di-n-propylamine	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
N-nitrosodi-n-butylamine					0 / 1		ND	ug/kg	A
N-nitrosodiethylamine					0 / 1		ND	ug/kg	A
N-nitrosodiphenylamine	0 / 1		ND	ug/kg					A

TABLE E.II-7
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNIT S	FREQ	MAX DET	UCL (95%)	UNIT S	
N-nitrosodiphenylamine	0 / 5		ND	ug/kg	0 / 5		ND	ug/kg	A
N-nitrosomethylethylamine					0 / 1		ND	ug/kg	A
N-nitrosomorpholine					0 / 1		ND	ug/kg	A
N-nitrosopiperidine					0 / 1		ND	ug/kg	A
N-nitrosopyrrolidine					0 / 1		ND	ug/kg	A
Naphthalene	0 / 7		ND	ug/kg	1 / 5	200	1,677	ug/kg	D
Nitrobenzene	0 / 7		ND	ug/kg	0 / 5		ND	ug/kg	A
o,o,o-Triethylphosphorothioate					0 / 3		ND	ug/kg	A
o-Toluidine					0 / 1		ND	ug/kg	A
P-Dimethylaminoazobenzene					0 / 1		ND	ug/kg	A
P-Phenylenediamine					0 / 1		ND	ug/kg	A
Pentachlorobenzene					0 / 1		ND	ug/kg	A
Pentachloroethane					0 / 1		ND	ug/kg	A
Pentachloronitrobenzene					0 / 1		ND	ug/kg	A
Pentachlorophenol	2 / 7	2600	1775.6699	ug/kg	0 / 5		ND	ug/kg	Retained
Phenacetin					0 / 1		ND	ug/kg	A
Phenanthrene	4 / 7	190	231.99557	ug/kg	3 / 5	15000	9,482	ug/kg	Retained
Phenol	3 / 7	650	391.28045	ug/kg	0 / 5		ND	ug/kg	D
Pronamide					0 / 1		ND	ug/kg	A
Pyrene	3 / 7	140	230.87059	ug/kg	3 / 5	14000	8,865	ug/kg	Retained
Safrole					0 / 1		ND	ug/kg	A
1,1,1,2-Tetrachloroethane					0 / 1		ND	ug/kg	A
1,1,1-Trichloroethane	0 / 6		ND	ug/kg	1 / 4	2	4.27	ug/kg	D

0832

E-II-74

4282

TABLE E.II-7
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNIT S	FREQ	MAX DET	UCL (95%)	UNIT S	
1,1,2,2-Tetrachloroethane	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A
1,1,2-Trichloroethane	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A
1,1-Dichloroethane	0 / 6		ND	ug/kg	2 / 5	110	71.2	ug/kg	D
1,1-Dichloroethene	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A
1,2-Dibromo-3-chloropropane					0 / 1		ND	ug/kg	A
1,2-Dibromoethane					0 / 1		ND	ug/kg	A
1,2-Dichloroethane	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A
1,2-Dichloroethylene					0 / 4		ND	ug/kg	A
1,2-Dichloropropane	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A
1,3-Dichloropropene	0 / 6		ND	ug/kg					A
2-Butanone	1 / 1	70	-	ug/kg	1 / 4	41	35.4	ug/kg	B
2-Chloro-1,3-butadiene					0 / 1		ND	ug/kg	A
2-Chloroethyl vinyl ether	0 / 6		ND	ug/kg					A
2-Hexanone	0 / 6		ND	ug/kg	1 / 4	2	8.56	ug/kg	D
3-Chloropropene					0 / 1		ND	ug/kg	A
4-Methyl-2-pentanone	0 / 6		ND	ug/kg	1 / 4	6	7.62	ug/kg	D
4-Methylphenolprophyl ether	0 / 1		ND	ug/kg					A
Acetone	1 / 6	750	474.16788	ug/kg	4 / 5	100	78.2	ug/kg	B
Acetonitrile					0 / 1		ND	ug/kg	A
Acrolein					0 / 1		ND	ug/kg	A
Acrylonitrile					0 / 1		ND	ug/kg	A
Benzene	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A
Bromodichloromethane	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A

4287

0833

E-II-75

TABLE E.II-7
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNIT S	FREQ	MAX DET	UCL (95%)	UNIT S	
Bromoform	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A
Bromomethane	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A
Carbon disulfide	0 / 6		ND	ug/kg	1 / 4	1	4.42	ug/kg	B
Carbon tetrachloride	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A
Chlorobenzene	0 / 6		ND	ug/kg	1 / 4	2	4.13	ug/kg	D
Chloroethane	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A
Chloroform	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A
Chloromethane	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A
Cis-1,3-dichloropropene					0 / 4		ND	ug/kg	A
Dibromochloromethane	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A
Dibromomethane					0 / 1		ND	ug/kg	A
Ethyl cyanide					0 / 1		ND	ug/kg	A
Ethyl methacrylate					0 / 1		ND	ug/kg	A
Ethylbenzene	1 / 6	270	188.55724	ug/kg	3 / 4	28	24.7	ug/kg	D
Iodomethane					0 / 1		ND	ug/kg	A
Methacrylonitrile					0 / 1		ND	ug/kg	A
Methyl methacrylate					0 / 1		ND	ug/kg	A
Methylene chloride	1 / 6	340	256.02973	ug/kg	1 / 5	56	38.6	ug/kg	B
Styrene	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A
Tech chlordane	0 / 1		ND	ug/kg					A
Tetrachloroethene	2 / 6	260	194.44572	ug/kg	0 / 4		ND	ug/kg	Retained
Toluene	1 / 6	50	114.84577	ug/kg	1 / 4	3	3.93	ug/kg	B
Total xylenes	1 / 6	890	499.99084	ug/kg	3 / 4	190	172	ug/kg	D

0834
E-II-76

TABLE E.II-7
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNIT S	FREQ	MAX DET	UCL (95%)	UNIT S	
Trans-1,2-dichloroethene	0 / 6		ND	ug/kg					A
Trans-1,3-dichloropropene					0 / 4		ND	ug/kg	A
Trans-1,4-dichloro-2-butene					0 / 1		ND	ug/kg	A
Trichloroethene	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A
Trichlorofluoromethane					0 / 1		ND	ug/kg	A
Vinyl acetate	0 / 6		ND	ug/kg	0 / 4		ND	ug/kg	A
Vinyl chloride	0 / 6		ND	ug/kg	1 / 4	3	8.59	ug/kg	Retained
1,2,3-Trichloropropane					0 / 1		ND	ug/kg	A

4787
2827

TABLE E.II-8

CLEARWELL MATERIAL ANALYTICAL RESULTS

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL	UNITS	FREQ	MAX DET	UCL	UNITS	
Ammonia, as nitrogen					5 / 5	151	161	mg/kg	G
Bromide					0 / 6		ND	mg/kg	A
Chloride					0 / 6		ND	mg/kg	A
Nitrate/nitrite					4 / 6	69	51.7	mg/kg	C
Oil & grease					5 / 5	288	252	mg/kg	F
Sulfate					4 / 4	572	580	mg/kg	C
Total Kjeldahl nitrogen					6 / 6	1060	921	mg/kg	F
Total organic carbon					6 / 6	85000	70,525	mg/kg	F
Total organic nitrogen					4 / 4	909	948	mg/kg	F
Total phosphorus					0 / 5		ND	mg/kg	A
pH					4 / 4	6.95	6.96	S.U.	F
Aluminum	4 / 4	23800	25432.646	mg/kg	6 / 6	20700	19,616	mg/kg	H
Antimony	2 / 4	32	27.002662	mg/kg	4 / 6	10.9	9.41	mg/kg	Retained
Arsenic	4 / 4	18	16.556105	mg/kg	5 / 6	59.1	54.0	mg/kg	Retained
Barium	4 / 4	6910	6141.5747	mg/kg	6 / 6	1790	1,612	mg/kg	Retained
Beryllium	4 / 4	9.1	7.7771414	mg/kg	6 / 6	2.9	2.34	mg/kg	Retained
Cadmium	2 / 4	7.2	7.2699518	mg/kg	6 / 6	2.9	2.73	mg/kg	Retained
Calcium	4 / 4	183000	180187.73	mg/kg	6 / 6	177000	167,699	mg/kg	C
Chromium	4 / 4	76	70.663160	mg/kg	6 / 6	196	153	mg/kg	Retained
Cobalt	2 / 4	23	23.821571	mg/kg	6 / 6	25.7	21.4	mg/kg	Retained
Copper	4 / 4	1120	1054.0981	mg/kg	6 / 6	3320	2,418	mg/kg	Retained

4282

0836

E-II-78

TABLE E.II-8
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL	UNITS	FREQ	MAX DET	UCL	UNITS	
Cyanide	1 / 4	9.2	7.8472940	mg/kg	4 / 6	1.47	1.09	mg/kg	Retained
Iron	4 / 4	21100	20897.941	mg/kg	6 / 6	20300	19,514	mg/kg	C
Lead	4 / 4	83	75.613848	mg/kg	6 / 6	588	433	mg/kg	Retained
Magnesium	4 / 4	44600	45859.480	mg/kg	6 / 6	27200	24,943	mg/kg	C
Manganese	4 / 4	1660	1655.5129	mg/kg	6 / 6	19800	13,249	mg/kg	Retained
Mercury	4 / 4	4.4	4.8015205	mg/kg	6 / 6	1.6	1.41	mg/kg	Retained
Molybdenum					6 / 6	40.9	36.5	mg/kg	Retained
Nickel	4 / 4	67	64.829959	mg/kg	6 / 6	228	167	mg/kg	Retained
Potassium	4 / 4	3650	3536.8033	mg/kg	6 / 6	4820	4,662	mg/kg	C
Selenium	1 / 4	3.7	3.1872075	mg/kg	4 / 6	0.85	0.617	mg/kg	Retained
Silver	1 / 4	3.3	3.1759023	mg/kg	5 / 6	12.7	9.84	mg/kg	Retained
Sodium	4 / 4	3500	3656.6100	mg/kg	6 / 6	1020	834	mg/kg	C
Thallium	1 / 4	2.1	1.8212474	mg/kg	4 / 6	1.6	1.26	mg/kg	Retained
Tin					5 / 6	24.1	18.1	mg/kg	Retained
Vanadium	4 / 4	2600	2201.1041	mg/kg	6 / 6	285	232	mg/kg	Retained
Zinc	4 / 4	194	177.12031	mg/kg	6 / 6	314	246	mg/kg	Retained
4,4-DDD	0 / 4		ND	ug/kg					A
4,4-DDE	0 / 4		ND	ug/kg					A
4,4-DDT	0 / 4		ND	ug/kg					A
Aldrin	0 / 4		ND	ug/kg					A
Alpha-BHC	0 / 4		ND	ug/kg					A

TABLE E.II-8
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL	UNITS	FREQ	MAX DET	UCL	UNITS	
Aroclor 1016	0 / 4		ND	ug/kg					A
Aroclor 1221	0 / 4		ND	ug/kg					A
Aroclor 1232	0 / 4		ND	ug/kg					A
Aroclor 1242	1 / 4	121	168.08344	ug/kg					Retained
Aroclor 1248	1 / 4	308	283.55379	ug/kg					Retained
Aroclor 1254	4 / 4	737	643.48989	ug/kg					Retained
Aroclor 1260	0 / 4		ND	ug/kg					A
Beta-BHC	0 / 4		ND	ug/kg					A
Chlordane	0 / 4		ND	ug/kg					A
Delta-BHC	0 / 4		ND	ug/kg					A
Dieldrin	0 / 4		ND	ug/kg					A
Endosulfan I	0 / 4		ND	ug/kg					A
Endosulfan II	0 / 4		ND	ug/kg					A
Endosulfan sulfate	0 / 4		ND	ug/kg					A
Endrin	0 / 4		ND	ug/kg					A
Endrin ketone	0 / 4		ND	ug/kg					A
Gamma-BHC (Lindane)	0 / 4		ND	ug/kg					A
Heptachlor	0 / 4		ND	ug/kg					A
Heptachlor epoxide	0 / 4		ND	ug/kg					A
Methoxychlor	0 / 4		ND	ug/kg					A
Toxaphene	0 / 4		ND	ug/kg					A

TABLE E.II-8
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL	UNITS	FREQ	MAX DET	UCL	UNITS	
1,2,4-Trichlorobenzene	0 / 4		ND	ug/kg					A
1,2-Dichlorobenzene	0 / 4		ND	ug/kg					A
1,3-Dichlorobenzene	0 / 4		ND	ug/kg					A
1,4-Dichlorobenzene	0 / 4		ND	ug/kg					A
2,4,5-Trichlorophenol	1 / 4	6200	5975.7299	ug/kg					Retained
2,4,6-Trichlorophenol	0 / 4		ND	ug/kg					A
2,4-Dichlorophenol	0 / 4		ND	ug/kg					A
2,4-Dimethylphenol	0 / 4		ND	ug/kg					A
2,4-Dinitrophenol	0 / 4		ND	ug/kg					A
2,4-Dinitrotoluene	0 / 4		ND	ug/kg					A
2,6-Dinitrotoluene	0 / 4		ND	ug/kg					A
2-Chloronaphthalene	0 / 4		ND	ug/kg					A
2-Chlorophenol	0 / 4		ND	ug/kg					A
2-Methylnaphthalene	0 / 4		ND	ug/kg					A
2-Methylphenol	0 / 4		ND	ug/kg					A
2-Nitroaniline	0 / 4		ND	ug/kg					A
2-Nitrophenol	0 / 4		ND	ug/kg					A
3,3-Dichlorobenzidine	0 / 4		ND	ug/kg					A
3-Nitroaniline	0 / 4		ND	ug/kg					A
4,6-Dinitro-2-methylphenol	0 / 4		ND	ug/kg					A
4-Bromophenyl phenyl ether	0 / 4		ND	ug/kg					A

1783

0830

E-II-81

0830

TABLE E.II-8
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL	UNITS	FREQ	MAX DET	UCL	UNITS	
4-Chloro-3-methylphenol	0 / 4		ND	ug/kg					A
4-Chloroaniline	0 / 4		ND	ug/kg					A
4-Chlorophenol phenyl ether	0 / 4		ND	ug/kg					A
4-Methylphenol	0 / 4		ND	ug/kg					A
4-Nitroaniline	0 / 4		ND	ug/kg					A
4-Nitrophenol	0 / 4		ND	ug/kg					A
Acenaphthene	0 / 4		ND	ug/kg					A
Acenaphthylene	0 / 4		ND	ug/kg					A
Anthracene	1 / 4	450	710.85609	ug/kg					D
Benzo(a)anthracene	2 / 4	890	916.87589	ug/kg					Retained
Benzo(a)pyrene	1 / 4	670	771.78598	ug/kg					Retained
Benzo(b)fluoranthene	1 / 4	710	791.79406	ug/kg					Retained
Benzo(g,h,i)perylene	1 / 4	230	725.40845	ug/kg					Retained
Benzo(k)fluoranthene	1 / 4	750	813.89587	ug/kg					Retained
Benzyl Alcohol	0 / 4		ND	ug/kg					A
Bis(2-chloroethyl)methane	0 / 4		ND	ug/kg					A
Bis(2-chloroethyl)ether	0 / 3		ND	ug/kg					A
Bis(2-chloroethyl)phthalate	0 / 1		ND	ug/kg					A
Bis(2-chloroisopropyl)ether	0 / 4		ND	ug/kg					A
Bis(2-ethylhexyl)phthalate	3 / 4	560	524.67178	ug/kg					B
Butyl benzyl phthalate	0 / 4		ND	ug/kg					A

4282

TABLE E.II-8
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL	UNITS	FREQ	MAX DET	UCL	UNITS	
Chrysene	3 / 4	1000	1003.8621	ug/kg					Retained
Di-n-butylphthalate	2 / 4	1700	1536.9830	ug/kg					B
Di-n-octylphthalate	0 / 4		ND	ug/kg					A
Dibenzo(a,h)anthracene	0 / 4		ND	ug/kg					A
Dibenzofuran	0 / 4		ND	ug/kg					A
Diethyl phthalate	1 / 4	410	709.07320	ug/kg					B
Dimethyl phthalate	0 / 4		ND	ug/kg					A
Fluoranthene	1 / 4	3100	2697.6101	ug/kg					Retained
Hexachlorobenzene	0 / 4		ND	ug/kg					A
Hexachlorobutadiene	0 / 4		ND	ug/kg					A
Hexachlorocyclopentadiene	0 / 4		ND	ug/kg					A
Hexachloroethane	0 / 4		ND	ug/kg					A
Indeno(1,2,3-cd)pyrene	1 / 4	270	719.14216	ug/kg					Retained
Isophorone	0 / 4		ND	ug/kg					A
N-nitroso-di-n-propylamine	0 / 4		ND	ug/kg					A
N-nitrosodiphenylamine	0 / 4		ND	ug/kg					A
Naphthalene	0 / 4		ND	ug/kg					A
Nitrobenzene	0 / 4		ND	ug/kg					A
Pentachlorophenol	0 / 4		ND	ug/kg					A
Phenanthrene	4 / 4	2100	1789.1240	ug/kg					Retained
Phenol	0 / 4		ND	ug/kg					A

4782

TABLE E.II-8
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL	UNITS	FREQ	MAX DET	UCL	UNITS	
Pyrene	3 / 4	1400	1300.3789	ug/kg					Retained
1,1,1-Trichloroethane	0 / 3		ND	ug/kg					A
1,1,2,2-Tetrachloroethane	0 / 3		ND	ug/kg					A
1,1,2-Trichloroethane	0 / 3		ND	ug/kg					A
1,1-Dichloroethane	0 / 3		ND	ug/kg					A
1,1-Dichloroethene	0 / 3		ND	ug/kg					A
1,2-Dichloroethane	0 / 3		ND	ug/kg					A
1,2-Dichloropropane	0 / 3		ND	ug/kg					A
1,3-Dichloropropene	0 / 3		ND	ug/kg					A
2-Hexanone	0 / 3		ND	ug/kg					A
4-Methyl-2-pentanone	0 / 3		ND	ug/kg					A
Acetone	1 / 3	2000	2476.8620	ug/kg					B
Benzene	0 / 3		ND	ug/kg					A
Bromodichloromethane	0 / 3		ND	ug/kg					A
Bromoform	0 / 3		ND	ug/kg					A
Bromomethane	0 / 3		ND	ug/kg					A
Carbon disulfide	0 / 3		ND	ug/kg					A
Carbon tetrachloride	0 / 3		ND	ug/kg					A
Chlorobenzene	0 / 3		ND	ug/kg					A
Chloroethane	0 / 3		ND	ug/kg					A
Chloroform	0 / 3		ND	ug/kg					A

TABLE E.II-8
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL	UNITS	FREQ	MAX DET	UCL	UNITS	
Chloromethane	0 / 3		ND	ug/kg					A
Dibromochloromethane	0 / 3		ND	ug/kg					A
Ethylbenzene	0 / 3		ND	ug/kg					A
Methylene chloride	1 / 3	870	1078.4847	ug/kg					B
Styrene	0 / 3		ND	ug/kg					A
Tetrachloroethene	0 / 3		ND	ug/kg					A
Toluene	0 / 3		ND	ug/kg					A
Total xylene	0 / 3		ND	ug/kg					A
Trans-1,2-dichloroethene	0 / 3		ND	ug/kg					A
Trichloroethene	0 / 3		ND	ug/kg					A
Vinyl acetate	0 / 3		ND	ug/kg					A
Vinyl chloride	0 / 3		ND	ug/kg					A

782

E-II-85

0843

TABLE E.II-9

PIT 1 MATERIAL ANALYSIS FOR RADIONUCLIDES

PARAMETER	CIS Data				RI/FS Data				Reason for Delection
	FREQ	MAX DET	UCL	UNITS	FREQ	MAX DET	UCL	UNITS	
Cesium-137	1/5	1.1	0.8	pCi/g	0/6		ND	pCi/g	Retained
Neptunium-237	0/5		ND	pCi/g				pCi/g	A
Plutonium-238	0/5		ND	pCi/g	0/5		ND	pCi/g	A
Plutonium-239/240	0/5		ND	pCi/g	0/6		ND	pCi/g	A
Radium-226					5/6	99.6	86.7	pCi/g	Retained
Radium-228					5/6	41	35.1	pCi/g	Retained
Ruthenium-106	0/5		ND	pCi/g	0/6		ND	pCi/g	A
Strontium-90	0/5		ND	pCi/g	5/6	7.69	4.7	pCi/g	Retained
Technetium-99	1/5	15	9.7	pCi/g	1/6	1.1	0.8	pCi/g	Retained
Thorium-228	5/5	52	37.8	pCi/g	1/4	131	433.3	pCi/g	Retained
Thorium-230	5/5	3600	2796.8	pCi/g	3/4	5460	6659.0	pCi/g	Retained
Thorium-232	5/5	55	39.8	pCi/g	1/4	131	246.1	pCi/g	Retained
Thorium-total					1/4	1180	2216.3	mg/kg	K
Uranium-234	5/5	1180	901.7	pCi/g	4/4	830	795.4	pCi/g	Retained
Uranium-235	5/5	151	108.0	pCi/g	5/5	259	179.1	pCi/g	Retained
Uranium-238	5/5	6980	4657.9	pCi/g	5/5	16160	10441.2	pCi/g	Retained
Uranium-total					6/6	48480	34973.8	mg/kg	Retained

TABLE E.II-10

PIT 2 MATERIAL ANALYSIS FOR RADIONUCLIDES

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cesium-137	2 / 5	3.6	2.5	pCi/g	2 / 4	0.5	0.7	pCi/g	Retained
Neptunium-237	0 / 5		ND	pCi/g	0 / 4		ND	pCi/g	A
Plutonium-238	2 / 5	0.1	0.1	pCi/g	0 / 4		ND	pCi/g	Retained
Plutonium-239/240	2 / 5	0.6	0.4	pCi/g	0 / 4		ND	pCi/g	Retained
Radium-226	0 / 5		ND	pCi/g	4 / 4	951	850	pCi/g	Retained
Radium-228	0 / 5		ND	pCi/g	4 / 4	437	382	pCi/g	Retained
Ruthenium-106	0 / 5		ND	pCi/g	2 / 4	4.7	6.0	pCi/g	Retained
Strontium-90	0 / 5		ND	pCi/g	3 / 4	3.99	4.4	pCi/g	Retained
Technetium-99	3 / 5	618	390	pCi/g	1 / 4	1.64	1.4	pCi/g	Retained
Thorium-228	5 / 5	164	121	pCi/g	2 / 2	697	912	pCi/g	Retained
Thorium-230	5 / 5	3980	2990	pCi/g	2 / 2	18400	60300	pCi/g	Retained
Thorium-232	5 / 5	88.0	69.5	pCi/g	1 / 2	268	528	pCi/g	Retained
Thorium-total				pCi/g	2 / 2	2780	3740	pCi/g	K
Uranium-234	5 / 5	18200	11500	pCi/g	2 / 2	1651	5370	pCi/g	Retained
Uranium-235	5 / 5	8780	5520	pCi/g	2 / 2	130	426	pCi/g	Retained
Uranium-238	5 / 5	17900	11900	pCi/g	2 / 2	1860	6064	pCi/g	Retained

0845

E-II-87

4282

TABLE E.II-11

PIT 3 MATERIAL ANALYSIS FOR RADIONUCLIDES

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cesium-137	0 / 7		ND	pCi/g	0 / 6		ND	pCi/g	A
Neptunium-237	3 / 7	2.1	1.1	pCi/g					Retained
Plutonium-238	3 / 7	1	0.5	pCi/g	1 / 5	0.98	0.7	pCi/g	Retained
Plutonium-239/240	3 / 7	14	6.0	pCi/g	2 / 5	1.59	1.4	pCi/g	Retained
Radium-226					6 / 6	451	306.4	pCi/g	Retained
Radium-228					6 / 6	241	186.2	pCi/g	Retained
Ruthenium-106	0 / 7		ND	pCi/g	0 / 6		ND	pCi/g	A
Strontium-90	1 / 7	5.2	2.6	pCi/g	4 / 6	4.91	2.8	pCi/g	Retained
Technetium-99	6 / 7	1110	521.2	pCi/g	6 / 6	33	22.7	pCi/g	Retained
Thorium-228	7 / 7	40	21.6	pCi/g	3 / 5	554	525.9	pCi/g	Retained
Thorium-230	7 / 7	11680	8317.1	pCi/g	6 / 6	11370	8574.5	pCi/g	Retained
Thorium-232	7 / 7	59	30.7	pCi/g	3 / 5	396	334.3	pCi/g	Retained
Thorium-total					3 / 5	3570	3007.8	mg/kg	K
Uranium-234	7 / 7	475	327.3	pCi/g	4 / 4	991	1112.0	pCi/g	Retained
Uranium-235	7 / 7	21	16.6	pCi/g	1 / 1	51.8	ERR	pCi/g	Retained
Uranium-235/236					4 / 4	89.2	82.8	pCi/g	Retained
Uranium-238	7 / 7	1380	762.2	pCi/g	6 / 6	1740	1294.8	pCi/g	Retained
Uranium-total					6 / 6	5938	4553.6	mg/kg	Retained

TABLE E.II-12

PIT 4 MATERIAL ANALYSIS FOR RADIONUCLIDES

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cesium-137	0 / 4		ND	pCi/g	0 / 6		ND	pCi/g	A
Neptunium-237	1 / 4	0.4	0.4	pCi/g					Retained
Plutonium-238	2 / 4	0.5	0.5	pCi/g					Retained
Plutonium-239/240	1 / 4	0.4	0.3	pCi/g					Retained
Radium-226					5 / 6	50.1	36.6	pCi/g	Retained
Radium-228					6 / 6	141	99.7	pCi/g	Retained
Ruthenium-106	0 / 4		ND	pCi/g	0 / 6		ND	pCi/g	A
Strontium-90	0 / 4		ND	pCi/g	5 / 6	144	99.4	pCi/g	Retained
Technetium-99	4 / 4	225	196.6	pCi/g	5 / 6	9.43	6.6	pCi/g	Retained
Thorium-228	4 / 4	395	334.6	pCi/g	4 / 4	2469	2316.5	pCi/g	Retained
Thorium-230	4 / 4	566	619.6	pCi/g	6 / 6	1815	1515.7	pCi/g	Retained
Thorium-232	4 / 4	92	80.2	pCi/g	4 / 4	838	708.0	pCi/g	Retained
Thorium-total					4 / 4	7565	6391.7	mg/kg	K
Uranium-234	4 / 4	2320	1993.3	pCi/g	3 / 3	4100	6064.6	pCi/g	Retained
Uranium-235	4 / 4	426	368.3	pCi/g	1 / 1	26.6		pCi/g	Retained
Uranium-235/236					4 / 4	934	897.7	pCi/g	Retained
Uranium-238	4 / 4	15800	13409.2	pCi/g	4 / 4	41900	44476.9	pCi/g	Retained
Uranium-total					6 / 6	115500	94413.9	mg/kg	Retained

TABLE E.II-13

PIT 5 MATERIAL ANALYSIS FOR RADIONUCLIDES

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cesium-137	2 / 6	76	52.8	pCi/g	9 / 9	78	40.2	pCi/g	Retained
Gross alpha					9 / 9	9400	4409.9	pCi/g	Retained
Gross beta					9 / 9	1020	817.1	pCi/g	Retained
Neptunium-237	5 / 6	19	15.1	pCi/g	2 / 2	46	80.5	pCi/g	Retained
Plutonium-238	5 / 6	4.4	3.6	pCi/g	3 / 9	0.3	0.1	pCi/g	Retained
Plutonium-239/240	5 / 6	13	9.7	pCi/g	5 / 9	3.72	1.2	pCi/g	Retained
Radium-226					9 / 9	150	111.7	pCi/g	Retained
Radium-228					8 / 9	39	26.7	pCi/g	Retained
Ruthenium-106	0 / 6		ND	pCi/g	2 / 9	1.6	1.4	pCi/g	Retained
Strontium-90	6 / 6	31	20.1	pCi/g	8 / 9	15	6.8	pCi/g	Retained
Technetium-99	6 / 6	2990	2069.3	pCi/g	9 / 9	3020	2020.4	pCi/g	Retained
Thorium-228	6 / 6	44	42.9	pCi/g	9 / 9	38	19.9	pCi/g	Retained
Thorium-230	6 / 6	8480	6813.5	pCi/g	9 / 9	2600	900.1	pCi/g	Retained
Thorium-232	6 / 6	55	45.1	pCi/g	7 / 9	10	4.7	pCi/g	Retained
Thorium-total					7 / 9	92	43.4	mg/kg	K
Uranium-234	6 / 6	1250	928.5	pCi/g	9 / 9	860	713.1	pCi/g	Retained
Uranium-235	6 / 6	79	53.9	pCi/g	4 / 9	39	24.6	pCi/g	Retained
Uranium-238	6 / 6	1230	902.8	pCi/g	9 / 9	960	746.0	pCi/g	Retained
Uranium-total					9 / 9	3700	2674.9	mg/kg	Retained

4282

TABLE E.II-14

PIT 6 MATERIAL ANALYSIS FOR RADIONUCLIDES

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cesium-137	3 / 4	31	31.2	pCi/g	8 / 8	14	10.8	pCi/g	Retained
Gross alpha					8 / 8	14000	11698.0	pCi/g	Retained
Gross beta					8 / 8	23000	18379.8	pCi/g	Retained
Neptunium-237	4 / 4	3.6	3.4	pCi/g					Retained
Plutonium-238	4 / 4	1.4	1.3	pCi/g	6 / 8	1	0.8	pCi/g	Retained
Plutonium-239/240	4 / 4	15	14.3	pCi/g	8 / 8	14	11.3	pCi/g	Retained
Radium-226					8 / 8	4.9	4.4	pCi/g	Retained
Radium-228					8 / 8	191	96.3	pCi/g	Retained
Ruthenium-106	0 / 4		ND	pCi/g	0 / 8		ND	pCi/g	A
Strontium-90	4 / 4	5.1	5.5	pCi/g	6 / 8	4.8	3.7	pCi/g	Retained
Technetium-99	4 / 4	164	166.8	pCi/g	5 / 8	45	31.1	pCi/g	Retained
Thorium-228	4 / 4	1.2	1.1	pCi/g	8 / 8	1.7	1.5	pCi/g	Retained
Thorium-230	4 / 4	44	47.6	pCi/g	8 / 8	62	45.9	pCi/g	Retained
Thorium-232	4 / 4	1.2	1.1	pCi/g	8 / 8	1	0.7	pCi/g	Retained
Uranium-234	4 / 4	5330	5064.3	pCi/g	8 / 8	4064	3123.9	pCi/g	Retained
Uranium-235	4 / 4	1750	1844.6	pCi/g	8 / 8	337	266.7	pCi/g	Retained
Uranium-238	4 / 4	18700	20506.3	pCi/g	8 / 8	28746	20552.8	pCi/g	Retained
Uranium-total					8 / 8	27733	19331.9	mg/kg	Retained

47876

0849

E-II-91

TABLE E.II-15

BURN PIT MATERIAL ANALYSIS FOR RADIONUCLIDES

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cesium-137	0 / 6		ND	pCi/g	0 / 4		ND	pCi/g	A
Neptunium-237	2 / 6	0.6	0.5	pCi/g					Retained
Plutonium-238	1 / 6	0.5	0.3	pCi/g	0 / 4		ND	pCi/g	Retained
Plutonium-239/240	1 / 6	0.4	0.2	pCi/g	0 / 4		ND	pCi/g	Retained
Radium-226					4 / 4	39.2	34.2	pCi/g	Retained
Radium-228					4 / 4	10.4	11.2	pCi/g	Retained
Ruthenium-106	0 / 6		ND	pCi/g	0 / 4		ND	pCi/g	A
Strontium-90	0 / 6		ND	pCi/g	1 / 4	0.5	0.5	pCi/g	Retained
Technetium-99	4 / 6	64	52.3	pCi/g	4 / 4	3.29	3.0	pCi/g	Retained
Thorium-228	6 / 6	19	12.9	pCi/g	3 / 4	12.4	378.3	pCi/g	Retained
Thorium-230	6 / 6	218	126.5	pCi/g	4 / 4	4530	3808.7	pCi/g	Retained
Thorium-232	6 / 6	21	13.2	pCi/g	3 / 4	14.4	173.2	pCi/g	Retained
Thorium-total					3 / 4	130	1562.6	mg/kg	K
Uranium-234	6 / 6	415	252.5	pCi/g	4 / 4	1711	1557.8	pCi/g	Retained
Uranium-235	6 / 6	27	16.1	pCi/g	4 / 4	102	101.4	pCi/g	Retained
Uranium-238	6 / 6	454	298.6	pCi/g	4 / 4	1996	1796.5	pCi/g	Retained
Uranium-total					4 / 4	4458	4033.1	mg/kg	Retained

TABLE E.II-16

CLEARWELL MATERIAL ANALYSIS FOR RADIONUCLIDES

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cesium-137	4 / 4	450	405.7	pCi/g	6 / 6	71.41	62.9	pCi/g	Retained
Gross alpha					6 / 6	2050	1553.1	pCi/g	Retained
Gross beta					6 / 6	1830	1464.8	pCi/g	Retained
Neptunium-237	3 / 4	2.2	2.1	pCi/g	4 / 6	1.8	1.7	pCi/g	Retained
Plutonium-238	0 / 4		ND	pCi/g	5 / 6	0.49	0.4	pCi/g	Retained
Plutonium-239/240	0 / 4		ND	pCi/g	5 / 6	0.54	0.4	pCi/g	Retained
Radium-226					6 / 6	170	117.6	pCi/g	Retained
Radium-228					6 / 6	26.4	24.1	pCi/g	Retained
Ruthenium-106	0 / 4		ND	pCi/g	0 / 6		ND	pCi/g	A
Strontium-90	4 / 4	26	22.3	pCi/g	2 / 6	12.8	7.2	pCi/g	Retained
Technetium-99	2 / 4	278	253.6	pCi/g	6 / 6	695	523.0	pCi/g	Retained
Thorium-228	4 / 4	56	54.9	pCi/g	6 / 6	28.1	26.8	pCi/g	Retained
Thorium-230	4 / 4	5600	4763.0	pCi/g	6 / 6	314	232.8	pCi/g	Retained
Thorium-232	4 / 4	39	36.9	pCi/g	6 / 6	9.69	7.7	pCi/g	Retained
Thorium-total					6 / 6	88.9	70.5	mg/kg	K
Uranium-234	4 / 4	376	364.4	pCi/g	6 / 6	1050	797.0	pCi/g	Retained
Uranium-235	4 / 4	49	48.3	pCi/g	6 / 6	373	348.6	pCi/g	Retained
Uranium-238	4 / 4	670	682.5	pCi/g	6 / 6	1640	1356.6	pCi/g	Retained
Uranium-total					6 / 6	2780	2092.8	mg/kg	Retained

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E-II-93

TABLE E.II-17

SURFACE SOIL - ANALYSIS FOR RADIONUCLIDES

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cesium-137	31 / 60	6	1.0	pCi/g	0 / 7		ND	pCi/g	Retained
Neptunium-237	1 / 60	0.5	0.1	pCi/g	0 / 7		ND	pCi/g	Retained
Plutonium-238	11 / 60	4.1	0.4	pCi/g	0 / 7		ND	pCi/g	Retained
Plutonium-239/240	10 / 60	0.8	0.1	pCi/g	0 / 7		ND	pCi/g	Retained
Radium-226					5 / 7	1.2	1.0	pCi/g	Retained
Radium-228					5 / 7	1.8	1.2	pCi/g	Retained
Ruthenium-106	0 / 60		ND	pCi/g	0 / 7		ND	pCi/g	A
Strontium-90	3 / 60	1.7	0.4	pCi/g	2 / 7	0.6	0.4	pCi/g	Retained
Technetium-99	18 / 60	93	8.7	pCi/g	1 / 7	0.9	0.6	pCi/g	Retained
Thorium-228	50 / 60	48	5.5	pCi/g	7 / 7	2.2	1.6	pCi/g	Retained
Thorium-230	59 / 60	972	74.9	pCi/g	7 / 7	6.1	3.9	pCi/g	Retained
Thorium-232	48 / 60	38	4.3	pCi/g	7 / 7	1.3	1.1	pCi/g	Retained
Uranium-234	60 / 60	298	60.1	pCi/g	7 / 7	5.3	4.2	pCi/g	Retained
Uranium-235	60 / 60	51	6.8	pCi/g	1 / 7	0.8	0.5	pCi/g	Retained
Uranium-238	60 / 60	1500	244.7	pCi/g	7 / 7	16.1	11.5	pCi/g	Retained
Uranium-total					5 / 5	62	52.2	mg/kg	Retained

TABLE E.II-18

SURFACE SOIL - ANALYSIS FOR CHEMICALS

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Aluminum					16/16	11700	6955.2	mg/kg	H
Antimony					16/16	32.5	27.2	mg/kg	Retained
Arsenic					16/16	6.4	4.9	mg/kg	Retained
Barium					16/16	92.3	56.9	mg/kg	Retained
Beryllium					16/16	1	0.8	mg/kg	Retained
Cadmium					16/16	7.7	5.8	mg/kg	Retained
Calcium					16/16	155000	117458.1	mg/kg	C
Chromium					16/16	18.8	14.3	mg/kg	Retained
Cobalt					16/16	17	10.4	mg/kg	Retained
Copper					16/16	20.1	17.0	mg/kg	Retained
Cyanide					4/16	0.71	0.3	mg/kg	D
Iron					16/16	23800	15511.5	mg/kg	C
Lead					16/16	34.3	15.9	mg/kg	Retained
Magnesium					16/16	39000	26294.6	mg/kg	C
Manganese					16/16	759	574.1	mg/kg	Retained
Mercury					1/16	0.11	0.1	mg/kg	D
Molybdenum					15/16	5.7	4.3	mg/kg	Retained
Nickel					16/16	50.2	29.4	mg/kg	Retained
Potassium					16/16	1210	919.7	mg/kg	C
Selenium					2/16	0.62	0.3	mg/kg	D
Silver					16/16	10.3	8.9	mg/kg	Retained

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E-II-95

TABLE E.II-18
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Sodium					14/16	185	136.1	mg/kg	C
Thallium					1/16	0.68	0.3	mg/kg	D
Vanadium					16/16	26.9	19.6	mg/kg	Retained
Zinc					16/16	79.9	46.7	mg/kg	Retained
4,4'-DDD					0/16		ND	ug/kg	A
4,4'-DDE					1/16	18	10.9	ug/kg	D
4,4'-DDT					0/16		ND	ug/kg	A
Aldrin					0/16		ND	ug/kg	A
Alpha-BHC					0/16		ND	ug/kg	A
Alpha-chlordane					0/16		ND	ug/kg	A
Aroclor-1016					0/16		ND	ug/kg	A
Aroclor-1221					0/16		ND	ug/kg	A
Aroclor-1232					0/16		ND	ug/kg	A
Aroclor-1242					0/16		ND	ug/kg	A
Aroclor-1248					0/16		ND	ug/kg	A
Aroclor-1254					3/16	1400	310.0	ug/kg	Retained
Aroclor-1260					1/16	200	112.1	ug/kg	D
Beta-BHC					0/16		ND	ug/kg	A
Delta-BHC					0/16		ND	ug/kg	A
Dieldrin					1/16	18	10.9	ug/kg	D
Endosulfan II					1/16	18	10.9	ug/kg	D

TABLE E.II-18
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Endosulfan sulfate					0/16		ND	ug/kg	A
Endosulfan-I					0/16		ND	ug/kg	A
Endrin					0/16		ND	ug/kg	A
Endrin ketone					0/16		ND	ug/kg	A
Gamma-BHC (lindane)					0/16		ND	ug/kg	A
Gamma-chlordane					0/16		ND	ug/kg	A
Heptachlor					0/16		ND	ug/kg	A
Heptachlor epoxide					0/16		ND	ug/kg	A
Methoxychlor					0/16		ND	ug/kg	A
Toxaphene					0/16		ND	ug/kg	A

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E-II-97

TABLE E.II-19

PIT 5 SURFACE WATER - ANALYSIS FOR RADIONUCLIDES

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cesium-137	2/2	90	193.6	pCi/L					Retained
Neptunium-237	0/2			pCi/L					A
Plutonium-238	0/2			pCi/L					A
Plutonium-239/240	0/2			pCi/L					A
Ruthenium-106	0/2			pCi/L					A
Strontium-90	2/2	41	59.6	pCi/L					Retained
Technetium-99	2/2	320	532.6	pCi/L					Retained
Thorium-228	0/2			pCi/L					A
Thorium-230	2/2	0.1	0.1	pCi/L					Retained
Thorium-232	0/2			pCi/L					A
Uranium-234	2/2	420	415	pCi/L					Retained
Uranium-235	2/2	19	18.5	pCi/L					Retained
Uranium-238	2/2	400	385	pCi/L					Retained

TABLE E.II-20

PIT 5 SURFACE WATER - ANALYSIS FOR CHEMICALS

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cyanide	2/2	87	140.1	ug/L					Retained
Aluminum	0/2		ND	ug/L					A
Antimony	2/2	4.5	6.1	ug/L					Retained
Arsenic	2/2	2.1		ug/L					Retained
Barium	2/2	108	118.6	ug/L					Retained
Beryllium	0/2		ND	ug/L					A
Cadmium	0/2		ND	ug/L					A
Calcium	2/2	184000	199942.0	ug/L					C
Chromium	0/2		ND	ug/L					A
Cobalt	0/2		ND	ug/L					A
Copper	2/2	21	23.7	ug/L					Retained
Iron	0/2		ND	ug/L					A
Lead	2/2	2.9	6.6	ug/L					Retained
Magnesium	2/2	387000	389657.0	ug/L					C
Manganese	1/2	2.3	5.4	ug/L					D
Mercury	0/2		ND	ug/L					A
Nickel	2/2	21	26.3	ug/L					Retained
Potassium	2/2	92000	208908.0	ug/L					C
Selenium	1/2	2.1	5.4	ug/L					Retained
Silver	0/2		ND	ug/L					A
Sodium	2/2	1320000	1771690.0	ug/L					C

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E-II-99

TABLE E.II.20
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Thallium	0/2		ND	ug/L					A
Vanadium	2/2	47	49.7	ug/L					Retained
Zinc	2/2	114	167.1	ug/L					Retained
4,4-DDD	0/1		ND	ug/L					A
4,4-DDE	0/1		ND	ug/L					A
4,4-DDT	0/1		ND	ug/L					A
Aldrin	0/1		ND	ug/L					A
Alpha-BHC	0/1		ND	ug/L					A
Aroclor 1016	0/1		ND	ug/L					A
Aroclor 1221	0/1		ND	ug/L					A
Aroclor 1232	0/1		ND	ug/L					A
Aroclor 1242	0/1		ND	ug/L					A
Aroclor 1248	0/1		ND	ug/L					A
Aroclor 1254	0/1		ND	ug/L					A
Aroclor 1260	0/1		ND	ug/L					A
Beta-BHC	0/1		ND	ug/L					A
Chlordane	0/1		ND	ug/L					A
Delta-BHC	0/1		ND	ug/L					A
Dieldrin	0/1		ND	ug/L					A
Endosulfan I	0/1		ND	ug/L					A
Endosulfan II	0/1		ND	ug/L					A

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E-II-100

4782

TABLE E.II.20
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Endosulfan sulfate	0/1		ND	ug/L					A
Endrin	0/1		ND	ug/L					A
Endrin ketone	0/1		ND	ug/L					A
Gamma-BHC (lindane)	0/1		ND	ug/L					A
Heptachlor	0/1		ND	ug/L					A
Heptachlor epoxide	0/1		ND	ug/L					A
Methoxychlor	0/1		ND	ug/L					A
Toxaphene	0/1		ND	ug/L					A
1,2,4-Trichlorobenzene	0/2		ND	ug/L					A
1,2-Dichlorobenzene	0/2		ND	ug/L					A
1,3-Dichlorobenzene	0/2		ND	ug/L					A
1,4-Dichlorobenzene	0/2		ND	ug/L					A
2,4,5-Trichlorophenol	0/2		ND	ug/L					A
2,4,6-Trichlorophenol	0/2		ND	ug/L					A
2,4-Dichlorophenol	0/2		ND	ug/L					A
2,4-Dimethylphenol	0/2		ND	ug/L					A
2,4-Dinitrophenol	0/2		ND	ug/L					A
2,4-Dinitrotoluene	0/2		ND	ug/L					A
2,6-Dinitrotoluene	0/2		ND	ug/L					A
2-Chloronaphthalene	0/2		ND	ug/L					A
2-Chlorophenol	0/2		ND	ug/L					A

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E-II-101-280 0859

TABLE E.II.20
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
2-Methylnaphthalene	0/2		ND	ug/L					A
2-Methylphenol	0/2		ND	ug/L					A
2-Nitroaniline	0/2		ND	ug/L					A
2-Nitrophenol	0/2		ND	ug/L					A
3,3-Dichlorobenzidine	0/2		ND	ug/L					A
3-Nitroaniline	0/2		ND	ug/L					A
4,6-Dinitro-2-methylphenol	0/2		ND	ug/L					A
4-Bromophenyl phenyl ether	0/2		ND	ug/L					A
4-Chloro-3-methylphenol	0/2		ND	ug/L					A
4-Chloroaniline	0/2		ND	ug/L					A
4-Chlorophenol phenyl ether	0/2		ND	ug/L					A
4-Methylphenol	0/2		ND	ug/L					A
4-Nitroaniline	0/2		ND	ug/L					A
4-Nitrophenol	0/2		ND	ug/L					A
Acenaphthene	0/2		ND	ug/L					A
Acenaphthylene	0/2		ND	ug/L					A
Anthracene	0/2		ND	ug/L					A
Benzo(a)anthracene	0/2		ND	ug/L					A
Benzo(a)pyrene	0/2		ND	ug/L					A
Benzo(b)fluoranthene	0/2		ND	ug/L					A

TABLE E.II.20
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Benzo(g,h,i)perylene	0/2		ND	ug/L					A
Benzo(k)fluoranthene	0/2		ND	ug/L					A
Benzyl alcohol	0/2		ND	ug/L					A
Bis(2-chloroethoxy)methane	0/2		ND	ug/L					A
Bis(2-chloroethyl)ether	0/2		ND	ug/L					A
Bis(2-chloroisopropyl)ether	0/2		ND	ug/L					A
Bis(2-ethylhexyl)phthalate	0/2		ND	ug/L					A
Butyl benzyl phthalate	0/2		ND	ug/L					A
Chrysene	0/2		ND	ug/L					A
Di-n-butylphthalate	0/2		ND	ug/L					A
Di-n-octylphthalate	0/2		ND	ug/L					A
Dibenzo(a,h)anthracene	0/2		ND	ug/L					A
Dibenzofuran	0/2		ND	ug/L					A
Diethyl phthalate	0/2		ND	ug/L					A
Dimethyl phthalate	0/2		ND	ug/L					A
Fluoranthene	0/2		ND	ug/L					A
Fluorene	0/2		ND	ug/L					A
Hexachlorobenzene	0/2		ND	ug/L					A
Hexachlorobutadiene	0/2		ND	ug/L					A
Hexachlorocyclopentadiene	0/2		ND	ug/L					A
Hexachloroethane	0/2		ND	ug/L					A

TABLE E.II.20
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Indeno(1,2,3-cd)pyrene	0/2		ND	ug/L					A
Isophorone	0/2		ND	ug/L					A
N-nitroso-di-n-propylamine	0/2		ND	ug/L					A
N-nitrosodiphenylamine	0/2		ND	ug/L					A
Naphthalene	0/2		ND	ug/L					A
Nitrobenzene	0/2		ND	ug/L					A
Pentachlorophenol	0/2		ND	ug/L					A
Phenanthrene	0/2		ND	ug/L					A
Phenol	0/2		ND	ug/L					A
Pyrene	0/2		ND	ug/L					A
1,1,1-Trichloroethane	0/2		ND	ug/L					A
1,1,2,2-Tetrachloroethane	0/2		ND	ug/L					A
1,1,2-Trichloroethane	0/2		ND	ug/L					A
1,1-Dichloroethane	0/2		ND	ug/L					A
1,1-Dichloroethene	0/2		ND	ug/L					A
1,2-Dichloroethane	0/2		ND	ug/L					A
1,2-Dichloropropane	0/2		ND	ug/L					A
1,3-Dichloropropene	0/2		ND	ug/L					A
2-Chloroethyl vinyl ether	0/2		ND	ug/L					A
2-Hexanone	0/2		ND	ug/L					A
4-Methyl-2-pentanone	0/2		ND	ug/L					A

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E-II-104

47821

TABLE E.II.20
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Acetone	0/2		ND	ug/L					A
Benzene	1/2	11	33.6	ug/L					Retained
Bromodichloromethane	0/2		ND	ug/L					A
Bromoform	0/2		ND	ug/L					A
Bromomethane	0/2		ND	ug/L					A
Carbon disulfide	0/2		ND	ug/L					A
Carbon tetrachloride	0/2		ND	ug/L					A
Chlorobenzene	0/2		ND	ug/L					A
Chloroethane	0/2		ND	ug/L					A
Chloroform	0/2		ND	ug/L					A
Chloromethane	0/2		ND	ug/L					A
Dibromochloromethane	0/2		ND	ug/L					A
Ethylbenzene	0/2		ND	ug/L					A
Methylene chloride	2/2	2	4.7	ug/L					B
Styrene	0/2		ND	ug/L					A
Tetrachloroethene	0/2		ND	ug/L					A
Toluene	1/2	1	6.5	ug/L					D
Total xylenes	0/2		ND	ug/L					A
Trans-1,2-dichloroethene	0/2		ND	ug/L					A
Trichloroethene	0/2		ND	ug/L					A
Vinyl acetate	0/2		ND	ug/L					A

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E-II-105

TABLE E.II.20
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Vinyl chloride	0/2		ND	ug/L					A

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E-II-106

TABLE E.II-21

PIT 6 SURFACE WATER - ANALYSIS FOR RADIONUCLIDES

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cesium-137	0/5			pCi/L					A
Neptunium-237	0/5			pCi/L					A
Plutonium-238	0/4			pCi/L					A
Plutonium-239/240	0/4			pCi/L					A
Radium-226	0/5			pCi/L					A
Radium-228	5/5	31.3	25.7	pCi/L					Retained
Ruthenium-106	0/5			pCi/L					A
Strontium-90	0/5			pCi/L					A
Technetium-99	5/5	3500	2747.4	pCi/L					Retained
Thorium-230	2/5	0.3	0.3	pCi/L					Retained
Thorium-232	0/5			pCi/L					A
Uranium-234	5/5	77	85.2	pCi/L					Retained
Uranium-235	5/5	9.3	9.9	pCi/L					Retained
Uranium-238	5/5	460	498.5	pCi/L					Retained

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E-II-107

TABLE E.II-22

PIT 6 SURFACE WATER - ANALYSIS FOR CHEMICALS

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
2,4-Dinitrophenol	0/4		ND	ug/L					A
2-Nitroaniline	0/4		ND	ug/L					A
3,3'-Dichlorobenzidine	0/4		ND	ug/L					A
3-Nitroaniline	0/4		ND	ug/L					A
4,6-Dinitro-2-methylphenol	0/3		ND	ug/L					A
4-Nitroaniline	0/4		ND	ug/L					A
4-Nitrophenol	0/4		ND	ug/L					A
Benzoic acid	0/2		ND	ug/L					A
Bis(2-ethyhexyl)phthalate	0/1		ND	ug/L					A
Di-n-octyl phthalate	0/1		ND	ug/L					A
Pentachlorophenol	0/4		ND	ug/L					A
Phosphoric acid, tributyl est	2/2	36	70.5	ug/L					D
Cyanide	1/5	10	8.1	mg/L					Retained
Aluminum	4/5	492	543.2	mg/L					C
Antimony	1/5	1.7	1.3	mg/L					Retained
Arsenic	0/5		ND	mg/L					A
Barium	0/5		ND	mg/L					A
Beryllium	0/5		ND	mg/L					A
Cadmium	0/5		ND	mg/L					A
Calcium	5/5	111000	115799.3	mg/L					C
Chromium	0/5		ND	mg/L					A

TABLE E.II-22
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cobalt	0/5		ND	mg/L					A
Copper	0/5		ND	mg/L					A
Iron	1/5	16	12.7	mg/L					C
Lead	1/5	2.9	2.0	mg/L					Retained
Magnesium	5/5	2430	1793.3	mg/L					C
Manganese	0/5		ND	mg/L					A
Mercury	0/5		ND	mg/L					A
Nickel	0/5		ND	mg/L					A
Potassium	5/5	42000	43411.1	mg/L					C
Selenium	0/5		ND	mg/L					A
Silver	0/5		ND	mg/L					A
Sodium	5/5	104000	104215.8	mg/L					C
Thallium	0/5		ND	mg/L					A
Vanadium	0/5		ND	mg/L					A
Zinc	2/5	114	72.8	mg/L					Retained
4,4-DDD	0/5		ND	ug/L					A
4,4-DDE	0/5		ND	ug/L					A
4,4-DDT	0/5		ND	ug/L					A
Aldrin	0/5		ND	ug/L					A
Alpha-BHC	0/5		ND	ug/L					A
Aroclor 1016	0/4		ND	ug/L					A

TABLE E.II-22
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Aroclor 1221	0/4		ND	ug/L					A
Aroclor 1232	0/4		ND	ug/L					A
Aroclor 1242	0/4		ND	ug/L					A
Aroclor 1248	0/4		ND	ug/L					A
Aroclor 1254	0/4		ND	ug/L					A
Aroclor 1260	0/4		ND	ug/L					A
Beta-BHC	0/5		ND	ug/L					A
Chlordane	0/4		ND	ug/L					A
Delta-BHC	0/5		ND	ug/L					A
Dieldrin	0/5		ND	ug/L					A
Endosulfan I	0/5		ND	ug/L					A
Endosulfan II	0/5		ND	ug/L					A
Endosulfan sulfate	0/5		ND	ug/L					A
Endrin	0/5		ND	ug/L					A
Endrin ketone	0/4		ND	ug/L					A
Gamma-BHC (lindane)	0/5		ND	ug/L					A
Heptachlor	0/5		ND	ug/L					A
Heptachlor epoxide	0/5		ND	ug/L					A
Methoxychlor	0/4		ND	ug/L					A
Toxaphene	0/4		ND	ug/L					A
1,2,4-Trichlorobenzene	0/4		ND	ug/L					A

TABLE E.II-22
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
1,2-Dichlorobenzene	0/4		ND	ug/L					A
1,3-Dichlorobenzene	0/4		ND	ug/L					A
1,4-Dichlorobenzene	0/4		ND	ug/L					A
2,4,5-Trichlorophenol	0/4		ND	ug/L					A
2,4,6-Trichlorophenol	0/4		ND	ug/L					A
2,4-Dichlorophenol	0/4		ND	ug/L					A
2,4-Dimethylphenol	0/4		ND	ug/L					A
2,4-Dinitrotoluene	0/4		ND	ug/L					A
2,6-Dinitrotoluene	0/4		ND	ug/L					A
2-Chloronaphthalene	0/4		ND	ug/L					A
2-Chlorophenol	0/4		ND	ug/L					A
2-Methylnaphthalene	0/4		ND	ug/L					A
2-Methylphenol	0/4		ND	ug/L					A
2-Nitrophenol	0/4		ND	ug/L					A
4,6-Dinitro-2-methylphenol	0/1		ND	ug/L					A
4-Bromophenyl phenyl ether	0/4		ND	ug/L					A
4-Chloro-3-methylphenol	0/4		ND	ug/L					A
4-Chloroaniline	0/4		ND	ug/L					A
4-Chlorophenol phenyl ether	0/4		ND	ug/L					A
4-Methylphenol	0/4		ND	ug/L					A
Acenaphthene	0/4		ND	ug/L					A

TABLE E.II-22
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Acenaphthylene	0/4		ND	ug/L					A
Anthracene	0/4		ND	ug/L					A
Benzo(a)anthracene	0/4		ND	ug/L					A
Benzo(a)pyrene	0/4		ND	ug/L					A
Benzo(b)fluoranthene	0/4		ND	ug/L					A
Benzo(g,h,i)perylene	0/4		ND	ug/L					A
Benzo(k)fluoranthene	0/4		ND	ug/L					A
Benzyl alcohol	0/4		ND	ug/L					A
Bis(2-chloroethoxy)methane	0/4		ND	ug/L					A
Bis(2-chloroethyl)ether	0/4		ND	ug/L					A
Bis(2-chloroisopropyl)ether	0/4		ND	ug/L					A
Bis(2-ethylhexyl)phthalate	0/3		ND	ug/L					A
Butyl benzyl phthalate	0/4		ND	ug/L					A
Chrysene	0/4		ND	ug/L					A
Di-n-butylphthalate	0/4		ND	ug/L					A
Di-n-octylphthalate	0/3		ND	ug/L					A
Dibenzo(a,h)anthracene	0/4		ND	ug/L					A
Dibenzofuran	0/4		ND	ug/L					A
Diethyl phthalate	0/4		ND	ug/L					A
Dimethyl phthalate	0/4		ND	ug/L					A
Fluoranthene	0/4		ND	ug/L					A

TABLE E.II-22
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Fluorene	0/4		ND	ug/L					A
Hexachlorobenzene	0/4		ND	ug/L					A
Hexachlorobutadiene	0/4		ND	ug/L					A
Hexachlorocyclopentadiene	0/4		ND	ug/L					A
Hexachloroethane	0/4		ND	ug/L					A
Indeno(1,2,3-cd)pyrene	0/4		ND	ug/L					A
Isophorone	0/4		ND	ug/L					A
N-nitroso-di-n-propylamine	0/4		ND	ug/L					A
N-nitrosodiphenylamine	0/4		ND	ug/L					A
Naphthalene	0/4		ND	ug/L					A
Nitrobenzene	0/4		ND	ug/L					A
Phenanthrene	0/4		ND	ug/L					A
Phenol	0/4		ND	ug/L					A
Pyrene	0/4		ND	ug/L					A
1,1,1-Trichloroethane	0/5		ND	ug/L					A
1,1,2,2-Tetrachloroethane	0/5		ND	ug/L					A
1,1,2-Trichloroethane	0/5		ND	ug/L					A
1,1-Dichloroethane	0/5		ND	ug/L					A
1,1-Dichloroethene	0/5		ND	ug/L					A
1,2-Dichloroethane	0/4		ND	ug/L					A
1,2-Dichloropropane	0/5		ND	ug/L					A

0871

E-II-113

4287

TABLE E.II-22
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
1,3-Dichloropropene	0/4		ND	ug/L					A
2-Chloroethyl vinyl ether	0/5		ND	ug/L					A
2-Hexanone	0/5		ND	ug/L					A
4-Methyl-2-pentanone	0/5		ND	ug/L					A
Acetone	0/5		ND	ug/L					A
Benzene	0/5		ND	ug/L					A
Bromodichloromethane	0/5		ND	ug/L					A
Bromoform	0/5		ND	ug/L					A
Bromomethane	0/1		ND	ug/L					A
Carbon disulfide	0/5		ND	ug/L					A
Carbon tetrachloride	0/5		ND	ug/L					A
Chlorobenzene	0/5		ND	ug/L					A
Chloroethane	0/5		ND	ug/L					A
Chloroform	0/5	3	2.7	ug/L					B
Chloromethane	0/5		ND	ug/L					A
Dibromochloromethane	0/5		ND	ug/L					A
Ethylbenzene	0/5		ND	ug/L					A
Methylene chloride	0/5		ND	ug/L					A
Styrene	0/5		ND	ug/L					A
Tetrachloroethene	0/5	2	2.2	ug/L					I
Toluene	0/5	6	4.5	ug/L					B

TABLE E.II-22
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Total xylene	0/5		ND	ug/L					A
Trans-1,2-dichloroethene	0/5		ND	ug/L					A
Trichloroethene	0/5		ND	ug/L					A
Vinyl acetate	0/5		ND	ug/L					A
Vinyl chloride	0/5		ND	ug/L					A

0873

E-II-115

47872

TABLE E.II-23

CLEARWELL SURFACE WATER - ANALYSIS FOR RADIONUCLIDES

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cesium-137	0/2			pCi/L					A
Plutonium-238	0/2			pCi/L					A
Plutonium-239/240	0/2			pCi/L					A
Radium-226	2/2	1.1	0.0	pCi/L					Retained
Radium-228	0/2			pCi/L					A
Ruthenium-106	0/2			pCi/L					A
Strontium-90	0/2			pCi/L					A
Technetium-99	2/2	4030	9476.9	pCi/L					Retained
Thorium-230	1/2	0.4	1.2	pCi/L					Retained
Thorium-232	0/2			pCi/L					A
Uranium-234	2/2	1900	2165.7	pCi/L					Retained
Uranium-235	2/2	120	146.6	pCi/L					Retained
Uranium-238	2/2	6200	8325.6	pCi/L					Retained

TABLE E.II-24

CLEARWELL SURFACE WATER - ANALYSIS FOR CHEMICALS

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Cyanide	1/2	87	304.9	ug/L					Retained
Aluminum	0/2		ND	ug/L					A
Antimony	0/2		ND	ug/L					A
Arsenic	2/2	4.2	6.6	ug/L					Retained
Barium	0/2		ND	ug/L					A
Beryllium	0/2		ND	ug/L					A
Cadmium	0/2		ND	ug/L					A
Calcium	2/2	112000	180816.3	ug/L					C
Chromium	0/2		ND	ug/L					A
Cobalt	0/2		ND	ug/L					A
Copper	2/2	19	32.3	ug/L					Retained
Iron	2/2	33	54.3	ug/L					C
Lead	0/2		ND	ug/L					A
Magnesium	2/2	155000	314951.4	ug/L					C
Manganese	2/2	20	62.5	ug/L					D
Mercury	0/2		ND	ug/L					A
Nickel	0/2		ND	ug/L					A
Potassium	2/2	28000	62541.0	ug/L					C
Selenium	1/2	3	8.7	ug/L					Retained
Silver	2/2	14	22.0	ug/L					Retained
Sodium	2/2	504000	1141680.0	ug/L					C

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E-II-117

4782

TABLE E.II-24
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Thallium	0/2		ND	ug/L					A
Vanadium	2/2	513	1814.9	ug/L					Retained
Zinc	2/2	47	153.3	ug/L					Retained
4,4-DDD	0/2		ND	ug/L					A
4,4-DDE	0/2		ND	ug/L					A
4,4-DDT	0/2		ND	ug/L					A
Aldrin	0/2		ND	ug/L					A
Alpha-BHC	0/2		ND	ug/L					A
Aroclor 1016	0/2		ND	ug/L					A
Aroclor 1221	0/2		ND	ug/L					A
Aroclor 1232	0/2		ND	ug/L					A
Aroclor 1242	0/2		ND	ug/L					A
Aroclor 1248	0/2		ND	ug/L					A
Aroclor 1254	0/2		ND	ug/L					A
Aroclor 1260	0/2		ND	ug/L					A
Beta-BHC	0/2		ND	ug/L					A
Chlordane	0/2		ND	ug/L					A
Delta-BHC	0/2		ND	ug/L					A
Dieldrin	0/2		ND	ug/L					A
Endosulfan I	0/2		ND	ug/L					A
Endosulfan II	0/2		ND	ug/L					A
Endosulfan sulfate	0/2		ND	ug/L					A

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E-II-118

TABLE E.II-24
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Endrin	0/2		ND	ug/L					A
Endrin ketone	0/2		ND	ug/L					A
Gamma-BHC (lindane)	0/2		ND	ug/L					A
Heptachlor	0/2		ND	ug/L					A
Heptachlor epoxide	0/2		ND	ug/L					A
Methoxychlor	0/2		ND	ug/L					A
Toxaphene	0/2		ND	ug/L					A
1,1,1-Trichloroethane	0/2		ND	ug/L					A
1,1,2,2-Tetrachloroethane	0/2		ND	ug/L					A
1,1,2-Trichloroethane	0/2		ND	ug/L					A
1,1-Dichloroethane	0/2		ND	ug/L					A
1,1-Dichloroethene	0/2		ND	ug/L					A
1,2-Dichloroethane	0/2		ND	ug/L					A
1,2-Dichloropropane	0/2		ND	ug/L					A
1,3-Dichloropropene	0/2		ND	ug/L					A
2-Chloroethyl vinyl ether	0/2		ND	ug/L					A
2-Hexanone	0/2		ND	ug/L					A
4-Methyl-2-pentanone	0/2		ND	ug/L					A
Acetone	1/2	520	1768.8	ug/L					B
Benzene	0/2		ND	ug/L					A
Bromodichloromethane	0/2		ND	ug/L					A
Bromoform	0/2		ND	ug/L					A

0877

E-II-1980

4282

TABLE E.II-24
(Continued)

PARAMETER	CIS DATA				RI/FS DATA				Reason for Deletion
	FREQ	MAX DET	UCL (95%)	UNITS	FREQ	MAX DET	UCL (95%)	UNITS	
Bromomethane	0/2		ND	ug/L					A
Carbon disulfide	0/2		ND	ug/L					A
Carbon tetrachloride	0/2		ND	ug/L					A
Chlorobenzene	0/2		ND	ug/L					A
Chloroethane	0/2		ND	ug/L					A
Chloroform	0/1		ND	ug/L					A
Chloromethane	0/2		ND	ug/L					A
Dibromochloromethane	0/2		ND	ug/L					A
Ethylbenzene	0/2		ND	ug/L					A
Methylene chloride	0/2		ND	ug/L					A
Styrene	0/2		ND	ug/L					A
Tetrachloroethene	0/2		ND	ug/L					A
Toluene	0/2		ND	ug/L					A
Total xylene	0/2		ND	ug/L					A
Trans-1,2-dichloroethene	0/2		ND	ug/L					A
Trichloroethene	0/2		ND	ug/L					A
Vinyl acetate	0/2		ND	ug/L					A
Vinyl chloride	0/2		ND	ug/L					A

0878
E-II-120
7780

4287

**OU1 RI ATTACHMENT E.III
TABLE OF CONTENTS**

4787

	<u>Page</u>
E.III.1 Introduction	E.III-1
E.III.2 Air Exposures	E.III-2
E.III.2.1 Inhalation	E.III-2
E.III.2.2 Ingestion of Vegetables Contaminated by Aerial Deposition	E.III-3
E.III.2.3 Ingestion of Meat or Milk Downwind of Source	E.III-6
E.III.2.4 Calculation of an ILCR from a Combination of All Airborne Exposure Pathways	E.III-11
E.III.3 Water Exposure	E.III-11
E.III.3.1 Drinking Water Ingestion Pathway	E.III-11
E.III.3.2 Incidental Ingestion of Surface Water While Swimming	E.III-13
E.III.3.3 Volatiles Released by Showering and Other Household Water Uses	E.III-14
E.III.3.4 Dermal Contact While Bathing	E.III-14
E.III.3.5 Irrigation of Vegetables	E.III-15
E.III.3.6 Ingestion of Beef and Dairy Products Produced with River Water	E.III-18
E.III.3.7 Ingestion of Fish	E.III-21
E.III.3.8 Calculation of ILCR for Great Miami River Uses Scenario	E.III-23
E.III.3.9 Risk Calculations for Vinyl Chloride in Water	E.III-24
E.III.4 Soil and Sediment Exposures	E.III-28
E.III.4.1 Incidental Ingestion of Soil or Sediment	E.III-28
E.III.4.2 Dermal Contact with Soil or Sediment	E.III-29
E.III.4.3 Ingestion of Vegetables Grown in Contaminated Soil	E.III-30
E.III.4.4 Ingestion of Meat or Milk	E.III-32
E.III.4.5 Direct Radiation Exposure	E.III-35
E.III.4.6 Calculation of Aggregate Risks for On-Property Resident From all Soil Pathways	E.III-36

0879

LIST OF TABLES

4787

<u>Table</u>	<u>Title</u>	<u>Page</u>
E.III-1	Parameters Used in Exposure Pathway Models	E.III-38
E.III-2	Intakes - Radionuclides (pCi) Current Conditions - Air Trespassing Child Under Current Land Use Without Access Controls	E.III-43
E.III-3	Intakes - Chemical Carcinogens (mg/kg/day) Current Conditions - Air Trespassing Child Under Current Land Use Without Access Controls	E.III-44
E.III-4	Intakes - Toxic Chemicals (mg/kg/day) Current Conditions - Air Trespassing Child Under Current Land Use Without Access Controls	E.III-45
E.III-5	Intakes - Radionuclides (pCi) Current Conditions - Surface Soil Trespassing Child Under Current Land Use Without Access Controls	E.III-46
E.III-6	Intakes - Chemical Carcinogens (mg/kg/day) Current Conditions - Surface Soil Trespassing Child Under Current Land Use Without Access Controls	E.III-47
E.III-7	Intakes - Toxic Chemicals (mg/kg/day) Current Conditions - Surface Soil Trespassing Child Under Current Land Use Without Access Controls	E.III-48
E.III-8	Intakes - Radionuclides (pCi) Current Conditions - Air Visitor Under Current Land Use With Access Controls	E.III-49
E.III-9	Intakes - Chemical Carcinogens (mg/kg/day) Current Conditions - Air Visitor Under Land Use With Access Controls	E.III-50
E.III-10	Intakes - Toxic Chemicals (mg/kg/day) Current Conditions - Air Visitor Under Current Land Use With Access Controls	E.III-51
E.III-11	Intakes - Radionuclides (pCi-yr/g) Current Conditions - Surface Soil Visitor Under Current Land Use With Access Controls	E.III-52
E.III-12	Intakes - Radionuclides (pCi) Current Conditions - Air Off-Property RME Adult Under All Land Uses	E.III-53
E.III-13	Intakes - Chemical Carcinogens (mg/kg/day) Current Conditions - Air Off-Property RME Adult Under All Land Uses	E.III-54
E.III-14	Intakes - Toxic Chemicals (mg/kg/day) Current Conditions - Air Off-Property RME Adult Under All Land Uses	E.III-55
E.III-15	Intakes - Radionuclides (pCi) Current Conditions - Surface Soil Off-Property User of Meat and Dairy Products Under Current Land Use	E.III-56
E.III-16	Intakes - Chemical Carcinogens (mg/kg/day) Current Conditions - Surface Soil Off-Property User of Meat and Dairy Products Under Current Land Use	E.III-57
E.III-17	Intakes - Toxic Chemicals (mg/kg/day) Current Conditions - Surface Soil Off-Property User of Meat and Dairy Products Under Current Land Use	E.III-58
E.III-18	Intakes - Radionuclides (pCi) Current Conditions - Surface Water Off-Property User of Meat and Dairy Products Under Current Land Use	E.III-59
E.III-19	Intakes - Chemical Carcinogens (mg/kg/day) Current Conditions - Surface Water Off-Property User of Meat and Dairy Products Under Current Land Use	E.III-60
E.III-20	Intakes - Toxic Chemicals (mg/kg/day) Current Conditions - Surface Water Off-Property User of Meat and Dairy Products Under Current Land Use	E.III-61

LIST OF TABLES
(Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
E.III-21	Intakes - Radionuclides (pCi) Future Conditions - Air Trespassing Child Under Current Land Use Without Access Controls	E.III-62
E.III-22	Intakes - Carcinogenic Chemicals (mg/kg/day) Future Conditions - Air Trespassing Child Under Current Land Use Without Access Controls	E.III-63
E.III-23	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Air Trespassing Child Under Current Land Use	E.III-64
E.III-24	Intakes - Radionuclides (pCi) Future Conditions - Surface Soil/Exposed Pit Materials Trespassing Child Under Current Land Use Without Access Controls	E.III-65
E.III-25	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Surface Soil/Exposed Pit Materials Trespassing Child Under Current Land Use Without Access Controls	E.III-66
E.III-26	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Surface Soil/Exposed Pit Materials Trespassing Child Under Current Land Use Without Access Controls	E.III-67
E.III-27	Intakes - Radionuclides (pCi) Future Conditions - Sediment Trespassing Child Under Current Land Use Without Access Controls	E.III-68
E.III-28	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Sediment Trespassing Child Under Current Land Use Without Access Controls	E.III-69
E.III-29	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Sediment Trespassing Child	E.III-70
E.III-30	Intakes - Radionuclides (pCi) Future Conditions - Air Off-Property RME Adult Under All Land Uses	E.III-71
E.III-31	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Air Off-Property RME Adult Under All Land Uses	E.III-72
E.III-32	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Air Off-Property RME Adult Under All Land Uses	E.III-73
E.III-33	Intakes - Radionuclides (pCi) Future Conditions - Groundwater Off-Property RME Adult Under All Land Uses	E.III-74
E.III-34	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Groundwater Off-Property RME Adult Under All Land Uses	E.III-75
E.III-35	Intakes - Radionuclides (pCi) Future Conditions - River Water Great Miami River User Under Current Land Use	E.III-76
E.III-36	Intakes Radionuclides (pCi) Future Conditions - Surface Soil Off-Property User of Meat and Dairy Products Under Current Land Use	E.III-77
E.III-37	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Surface Soil Off-Property User of Meat and Dairy Products Under Current Land Use	E.III-78
E.III-38	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Surface Soil Off-Property User of Meat and Dairy Products Under Current Land Use	E.III-79
E.III-39	Intakes - Radionuclides (pCi) Future Conditions - Surface Water Off-Property User of Meat and Dairy Products Under Current Land Use	E.III-80

LIST OF TABLES
(Continued)

4787

<u>Table</u>	<u>Title</u>	<u>Page</u>
E.III-40	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Surface Water Off-Property User of Meat and Dairy Products Under Current Land Use	E.III-81
E.III-41	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Surface Water Off-Property User of Meat and Dairy Products Under Current Land Use	E.III-82
E.III-42	Intakes - Radionuclides (pCi) Future Conditions - Air On-Property RME Adult Under Future Land Use	E.III-83
E.III-43	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Air On-Property RME Adult Under Future Land Use	E.III-84
E.III-44	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Air On-Property RME Adult Under Future Land Use	E.III-85
E.III-45	Intakes - Radionuclides (pCi) Future Conditions - Surface Soil On-Property RME Adult - Food Ingestion	E.III-87
E.III-46	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Surface Soil On-Property RME Adult - Food Ingestion	E.III-88
E.III-47	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Surface Soil Off-Property RME Adult - Food Ingestion	E.III-89
E.III-48	Intakes - Radionuclides (pCi) Future Conditions - Surface Water On-Property RME Adult Under Future Land Use	E.III-90
E.III-49	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Surface Water On-Property RME Adult Under Future Land Use	E.III-91
E.III-50	Intakes - Toxic Chemicals Future Conditions - Surface Water On-Property RME Adult Under Future Land Use	E.III-92
E.III-51	Intakes - Radionuclides (pCi) Future Conditions - Surface Soil Exposed Pit Materials On-Property RME Adult Under Future Land Use	E.III-93
E.III-52	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Surface Soil/ Exposed Pit Materials On-Property RME Adult Under Future Land Use	E.III-94
E.III-53	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Surface Soil/ Exposed Pit Contents On-Property RME Adult Under Future Land Use	E.III-95
E.III-54	Intakes - Radionuclides (pCi) Future Conditions - Groundwater On-Property RME Adult Under Future Land Use	E.III-96
E.III-55	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Groundwater On-Property RME Adult Under All Land Uses	E.III-97
E.III-56	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Groundwater On-Property RME Adult Under Future Land Use	E.III-98
E.III-57	Intakes - Radionuclides (pCi) Future Conditions - Perched Water On-Property RME Adult Under Future Land Use	E.III-99
E.III-58	Intakes - Chemical Chemocarcinogens (mg/kg/day) Future Conditions - Perched Water On-Property RME Adult Under Future Land Use	E.III-100
E.III-59	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Perched Water On-Property RME Adult Under Future Land Use	E.III-101
E.III-60	Intakes - Radionuclides (pCi) Future Conditions - Air On-Property CT Adult Under Future Land Use	E.III-103

LIST OF TABLES
(Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
E.III-61	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Air On-Property CT Adult Under Future Land Use	E.III-104
E.III-62	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Air On-Property CT Adult Under Future Land Use	E.III-105
E.III-63	Intakes - Radionuclides (pCi) Future Conditions - Surface Soil On-Property CT Adult - Food Ingestion	E.III-106
E.III-64	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Surface Soil On-Property CT Adult - Food Ingestion	E.III-107
E.III-65	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Surface Soil On-Property CT Adult - Food Ingestion	E.III-108
E.III-66	Intakes - Radionuclides (pCi) Future Conditions - Surface Water On-Property CT Resident Adult Under Future Land Use	E.III-109
E.III-67	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Surface Water On-Property CT Resident Adult Under Future Land Use	E.III-110
E.III-68	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Surface Water On-Property CT Resident Adult Under Future Land Use	E.III-111
E.III-69	Intakes - Radionuclides (pCi) Future Conditions - Surface Soil/Exposed Pit Material On-Property CT Adult Under Future Land Use	E.III-112
E.III-70	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Surface Soil/Exposed Pit Contents On-Property CT Adult Under Future Land Use	E.III-113
E.III-71	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Surface Soil/Exposed Pit Contents On-Property CT Adult Under Future Land Use	E.III-114
E.III-72	Intakes - Radionuclides (pCi) Future Conditions - Groundwater On-Property CT Adult Under Future Land Use	E.III-115
E.III-73	Intakes - Chemical Chemocarcinogens (mg/kg/day) Future Conditions - Groundwater On-Property CT Adult Under All Future Uses	E.III-116
E.III-74	Intakes - Toxic Chemicals (mg/kg/day) future Conditions - Groundwater On-Property CT Adult Under Future Land Use	E.III-117
E.III-75	Intakes - Radionuclides (pCi) Future Conditions - Perched Water On-Property CT Adult Under Future Land Use	E.III-118
E.III-76	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Perched Water On-Property CT Adult Under Future Land Use	E.III-119
E.III-77	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Perched Water On-Property CT Adult Under Future Land Use	E.III-120
E.III-78	Intakes - Radionuclides (pCi) Future Conditions - Air On-Property RME Child Under Future Land Use	E.III-122
E.III-79	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Air On-Property RME Child Under Future Land Use	E.III-123
E.III-80	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Air On-Property RME Child Under Future Land Use	E.III-124

LIST OF TABLES
(Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
E.III-81	Intakes - Radionuclides (pCi) Future Conditions - Surface Soil On-Property RME Child - Food Ingestion (Pits 1 & 2)	E.III-126
E.III-82	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Surface Soil On-Property RME Child - Food Ingestion	E.III-127
E.III-83	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Surface Soil On-Property RME Child - Food Ingestion	E.III-128
E.III-84	Intakes - Radionuclides (pCi) Future Conditions - Surface Soil/Exposed Pit Contents On-Property RME Child Under Future Land Use	E.III-129
E.III-85	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Surface Soil/Exposed Pit Materials On-Property RME Child Under Future Land Use	E.III-130
E.III-86	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Surface Soil/Exposed Pit Materials On-Property RME Child Under Future Land Use	E.III-131
E.III-87	Intakes - Radionuclides (pCi) Future Conditions - Surface Water On-Property RME Resident Child Under Future Land Use	E.III-132
E.III-88	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Surface Water On-Property RME Resident Child Under Future Land Use	E.III-133
E.III-89	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Surface Water On-Property RME Resident Child Under Future Land Use	E.III-134
E.III-90	Intakes - Radionuclides (pCi) Future Conditions - Groundwater On-Property RME Child Under Future Land Use	E.III-135
E.III-91	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Groundwater On-Property RME Child Under Future Land Use	E.III-136
E.III-92	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Groundwater On-Property RME Child Under Future Land Use	E.III-137
E.III-93	Intakes - Radionuclides (pCi) Future Conditions - Perched Water On-Property RME Adult Under Future Land Use	E.III-138
E.III-94	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Perched Water On-Property RME Child Under Future Land Use	E.III-139
E.III-95	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Perched Water On-Property RME Child Under Future Land Use	E.III-140
E.III-96	Intakes - Radionuclides (pCi) Future Conditions - Air On-Property Home Builder Under Future Land Use	E.III-142
E.III-97	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Air On-Property Home Builder Under Future Land Use	E.III-143
E.III-98	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Air On-Property Home Builder Under Future Land Use	E.III-144
E.III-99	Intakes - Radionuclides (pCi) Future Conditions - Surface Soil/Exposed Pit Contents On-Property Home Builder Under Future Land Use	E.III-145

4787

LIST OF TABLES
(Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
E.III-100	Intakes - Chemical Carcinogens (mg/kg/day) Future Conditions - Surface Soil/Exposed Pit Contents On-Property Home Builder Under Future Land Use	E.III.146
E.III-101	Intakes - Toxic Chemicals (mg/kg/day) Future Conditions - Surface Soil/Exposed Pit Contents On-Property Home Builder Under Future Land use	E.III-147

ATTACHMENT E.III**EXAMPLE CALCULATIONS OF INTAKES AND RISKS
FOR OPERABLE UNIT 1 BASELINE RISK ASSESSMENT**

ATTACHMENT E.III

4787

EXAMPLE CALCULATIONS OF INTAKES AND RISKS
FOR OPERABLE UNIT 1 BASELINE RISK ASSESSMENT

E.III.1 INTRODUCTION

EPA's CERCLA methodology, which is set forth in recent guidance such as the Risk Assessment Guidance for Superfund Volume 1, Human Health Evaluation Manual (Part A) (EPA 1989a) and its supporting documents, uses a specific methodology to calculate human health effects. Exposures are first quantified using a set of equations and parameters that are unique to each exposure pathway. The exposure assessment process results in calculated daily intakes (expressed in mg/kg-d) for hazardous chemical contaminants and radioactivity intakes (expressed in pCi) for radionuclide contaminants. The calculated intakes are multiplied then by an appropriate slope factor to calculate risk, or divided by a constituent's Rfd to yield a Hazard Index (HQ). The exposure-to-risk relationship represented by the slope factors cited in the Health Effects Summary Tables (HEAST) (1992b), are linear below risk levels of 10^{-2} . This assessment uses the linear relationship to calculate combined Incremental Lifetime Cancer Risks (ILCRs) up to 1×10^{-2} . The relationship becomes exponential between cancer risk levels of 10^{-2} and 10^{-1} , but remains essentially linear (to within 10 percent) up to a risk value of 2×10^{-1} . Since the methodology employed in this assessment yields calculated risks in excess of 10^{-2} for OU1, Risks above this risk range are calculated using the one-hit methodology presented in Section 8.2.1 of EPA guidance (EPA 1989a).

This section presents examples of the calculations used to quantify the magnitude of exposure, risk, and toxic health effects expected to result from all reasonable exposure pathways involving U-238 at the FEMP. This radionuclide is chosen for these examples because it is present in all media, and uranium contributes to both risk and toxic effects calculated for the operable unit. All parameters and equations are drawn from the FEMP Risk Assessment Work Plan Addendum (DOE 1992a) unless noted otherwise. Tables E.3-15 and E.3-16 in the Baseline Risk Assessment and Table E.III-1 of this attachment list the parameters used to evaluate the exposures examined in this assessment.

For convenience, the equations used to quantify risk are grouped together according to exposure media. The exposure media considered are water, air, and soil. Exposures from sediment are included in the group detailing the soil exposure pathways. Section E.III.2 presents the methodology followed for exposures to air, Section E.III.3 describes the methodology followed for exposures to water, and Section E.III.4 relates the methodology followed for exposures to soil.

4787

E.III.2 AIR EXPOSURES

The on-property resident RME is used to illustrate the calculation of risks associated with air pathways. This hypothetical individual is the limiting receptor for air exposures from Operable Unit 1.

E.III.2.1 Inhalation

Equations 7-5 and 7-6 from the Risk Assessment Work Plan Addendum (DOE 1992a) are used to quantify intake from the inhalation pathway:

$$\text{(radionuclides)} \quad I_{ai} = (C_{ai})(IR)(ET)(EF)(ED) \quad (\text{E.III-1})$$

$$\text{(chemicals)} \quad I_{ai} = (C_{ai})(IR)(ET)(EF)(ED)/(BW)(AT) \quad (\text{E.III-2})$$

where

- I_{ai} = intake from inhalation (pCi, rad) (mg/kg-d, chem)
- C_{ai} = concentration in air (pCi/m³, rad) (mg/m³, chem)
- IR = inhalation rate (m³/h)
- ET = exposure time (h/d)
- EF = exposure frequency (d/y)
- ED = exposure duration (y)
- BW = body weight (kg); and
- AT = averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)

Intakes resulting from inhaling air containing 1 pCi/m³ of U-238 have been selected for the example calculation. The inhalation rate for an adult is 0.83 m³/h. The exposure duration is 70 years (ED = 70 y/lifetime) and the exposure frequency is 350 days out of every year (EF = 350 d/y). The exposure time is 5.7 h/d (ET = 5.7 h/d). Substituting these values into Equation E.III-1 yields:

$$\begin{aligned} I_{a \text{ U238}} &= (1 \text{ pCi/m}^3)(0.83 \text{ m}^3/\text{h})(5.7 \text{ h/d})(350 \text{ d/y})(70 \text{ y/lifetime}) \\ I_{a \text{ U238}} &= 115,910 \text{ pCi/lifetime} \end{aligned} \quad (\text{E.III-3})$$

The exposure model used in this scenario responds linearly to changes in concentration. After rounding to three significant figures, each pCi/m³ of U-238 in air is calculated to result in an incremental lifetime intake of about 116,000 pCi of U-238 via respiration.

The ILCR to this receptor for this pathway from this radionuclide is:

$$\text{ILCR}_{a \text{ U238}} = \text{SF}_{\text{inh U238}} \times I_{a \text{ U238}} \quad (\text{E.III-4})$$

where

4787

$ILCR_{U238} = ILCR \text{ from breathing air (r/lifetime)}$

$SF_{inh i} = \text{Slope factor for inhalation of constituent "i" (r/pCi)}$

The relationship between air concentration and risk for this receptor, pathway, and radionuclide is determined by substituting the lifetime intake of U-238 calculated in Equation E.III-3 and the inhalation slope factor for U-238, $5.2 \times 10^{-8} \text{ r/pCi}$, for $SF_{inh i}$ into Equation E.III-4. This yields:

$$ILCR_{U238} = (5.2 \times 10^{-8} \text{ r/pCi})(115910 \text{ pCi/lifetime}) \quad (\text{E.III-5})$$

$$ILCR_{U238} = 0.00603 \text{ r/lifetime}$$

Because the exposure model used in this scenario responds linearly to changes in concentration, each additional pCi/m^3 of U-238 in air is predicted to result in a calculated excess risk of 6×10^{-3} .

E.III.2.2 Ingestion of Vegetables Contaminated by Aerial Deposition

Eating vegetables contaminated by aerial deposition of contaminated dust can contribute to the total intake of contaminants by humans. Estimating the magnitude of this intake is a two step process. First the concentration in the vegetables is estimated. Then the lifetime intake is calculated. If measured values are not available (e.g. future exposures), this concentration is estimated using Equation 7-10 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992a). The intake equation is:

$$C_{avi} = d_d \left[\frac{r_d(1 - e^{-\lambda_w t})}{Y\lambda_w} + \frac{f_d B_{iv(n)} CF_p (1 - e^{-\lambda_{di} t})}{\rho \lambda_{di}} \right] e^{-\lambda_{ri} t} \quad (\text{E.III-6})$$

where

- C_{avi} = concentration of the i^{th} contaminant in/on vegetables and fruit (pCi/g , rad) (mg/kg, chem)
- λ_{di} = effective depletion constant of i^{th} contaminant in surface soils due to radioactive decay, chemical degradation, and leaching (h^{-1})
- λ_w = effective depletion constant of i^{th} contaminant on the surface plants also known as the weathering removal rate (h^{-1})
- λ_{ri} = radioactive or chemical decay constant of i^{th} contaminant (h^{-1})
- $B_{iv(n)}$ = dry soil to wet plant partitioning coefficient of i^{th} contaminant in feed and forage ($n=1$) or food crops ($n=2$) (C_{iv}/C_s)
- CF_p = Dry to wet weight conversion factor (0.428 for crops, Baes and Sharp, 1984; 1.0 for feed and forage)
- d_d = constituent's deposition rate ($\text{pCi/m}^2\text{-h}$, rad) ($\text{mg/m}^2\text{-h}$, chem)
- f_d = fraction of year plant is down wind (unitless)

4387

r_d	=	fraction of airborne material retained on plant surface (unitless)	1
t_e	=	growing season (h)	2
t_{bd}	=	duration soil is exposed to airborne emissions (h)	3
t_h	=	duration of period between harvest and consumption (h)	4
Y	=	agricultural yield (g/m^2 , rad)(kg/m^2 , chem)	5
ρ	=	effective dry surface soil density (g/m^2 , rad)(kg/m^2 , chem)	6

The soil depletion coefficient is calculated by

$$\lambda_{di} = \lambda_{ri} + \lambda_{Li} \quad (\text{E.III-7})$$

where the leaching coefficient (λ_{Li}) is calculated using the relationship (Baes and Sharp 1983):

$$\lambda_L = \frac{V_w}{z \theta \left[1 + \frac{K_d}{\theta} \right]} \quad (\text{E.III-8})$$

and

λ_{Li}	=	Leach rate (h^{-1})	11
V_w	=	Percolation rate (nominally 0.0044 cm/h through Pits 1 and 2)	12
z	=	Depth of surface soil (15 cm)	13
σ	=	Density of soil in root zone (nominally 1.5 g/cm^3)	14
K_d	=	Water to soil partitioning coefficient (cm^3/g)	15
θ	=	Moisture fraction of surface soil (measured at 0.17)	16

When measured air concentration data are available, the aerial deposition rate of a constituent per unit area (d_d) is estimated by multiplying the concentration in air by the mean deposition velocity (V m/h):

$$d_d = (C_a \cdot U_{238} \text{ pCi/m}^3)(V \text{ m/h}) \quad (\text{E.III-9})$$

Vegetables grown in air containing particles of U-238 have been selected for the example calculation. Assuming that the mean deposition velocity for dust in the study area (V) is about 0.0018 m/s (EPA 1991e), the aerial deposition rate of U-238 (d_d) per unit area calculated by Equation E.III-9 is $\text{pCi/m}^2/\text{h}$. Assuming the vegetables are centered in the study area, they will always be downwind, so (f_d) is unity (1). The duration of time which the vegetable plot is exposed to aerial deposition during the study period (t_{bd}) is 1000 years (8.76×10^6 h). The fraction of airborne material retained on the plant surface (r_d) is 0.25. The weathering removal rate (λ_w) is 0.0021 h^{-1} . The dry soil to dry plant partitioning coefficient of U-238 in the reproductive portions of vegetables ($B_{iv(2)}$) is 4×10^{-3} . The dry plant mass to wet plant mass ratio is 0.428 (CF_p). The effective dry surface density of the soil (ρ) is $225,000 \text{ g/m}^2$. The agricultural yield is 1500 g/m^2 (Y), and the growing season (t_e) is 1440 hours. The period between harvest and consumption (t_h) is 24 hours. The radiological decay constant of U-

238 (λ_{vi}) is $1.77 \times 10^{-14} \text{ h}^{-1}$. This value is so small that the $\exp(-\lambda_{vi} t_h)$ term approaches unity (1) (i.e. no significant decay). A value of 1.61×10^{-5} is calculated for λ_{vi} using Equation E.III-8 and a K_d of $12 \text{ cm}^3/\text{g}$ from Appendix D. The effective depletion constant (λ_{vi}) is calculated from Equation E.III-7 to be 1.61×10^{-5} . Substituting these parameter values into Equation E.III-5 and simplifying yields:

$$C_{avi} = (6.48 \text{ pCi/m}^2/\text{h}) \left[\frac{(0.25)(1 - e^{-(0.0021 \text{ h}^{-1})(1440 \text{ h})})}{(1500 \text{ g/m}^2)(0.0021 \text{ h}^{-1})} + \frac{(1)(0.004)(0.483)(1 - e^{-(1.61 \times 10^{-5} \text{ h}^{-1})(8760000 \text{ h})})}{(225000 \text{ g/m}^2)(1.61 \times 10^{-5} \text{ h}^{-1})} \right] \quad (\text{E.III-10})$$

$$C_{av \text{ U238}} = 0.0492 \text{ pCi/g}$$

Once the constituent's concentration in the vegetables and fruit is estimated, the resulting intake by humans can be estimated using Equations 7-15 and 7-16 of the FEMP Risk Assessment Work Plan Addendum (DOE 1992a):

$$(\text{radionuclides}) \quad I_{avi} = (C_{avi})(IR)(FI)(EF)(ED) \quad (\text{E.III-11})$$

$$(\text{chemicals}) \quad I_{avi} = (C_{avi})(IR)(FI)(EF)(ED)/(BW)(AT) \quad (\text{E.III-12})$$

where

- I_{avi} = intake from vegetation (pCi, rad) (mg/kg-d, chem)
- C_{avi} = total concentration of contaminants in vegetable (pCi/g, rad) (mg/kg, chem)
- IR = ingestion rate (g/d, rad) (kg, chem)
- FI = fraction ingested from contaminated source (unitless)
- EF = exposure frequency (d/y)
- ED = exposure duration (y)
- BW = body weight (kg); and
- AT = averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y).

Continuing the example begun in Equation E.III-10, ingestion of vegetables and fruit containing a U-238 concentration of C_{avi} of 0.0492 pCi/g for a 70-year lifetime has been selected to illustrate the methodology used to calculate human intake of constituents from plants. The exposure frequency is 350 days per year (EF = 350 d/y). The consumption rate of fruit and vegetables grown in the study area is 122 grams per day (FI x IR = 122 g/d). The exposure duration (ED) is 70 y/lifetime. The lifetime intake of U-238 from this food supply is given by Equation E.III-11. Using the presented parameter values, this becomes:

$$I_{av \text{ U238}} = (0.492 \text{ pCi/g})(122 \text{ g/d})(350 \text{ d/y})(70 \text{ y/lifetime}) \quad (\text{E.III-13})$$

$$I_{av \text{ U238}} = 1,470,588 \text{ pCi/lifetime}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they estimate that each additional pCi/m³ of U-238 in air will produce an incremental lifetime intake of about 1,470,588 pCi U-238 via this pathway.

The ILCR to this receptor for this pathway from this radionuclide is:

$$ILCR_{av \text{ U238}} = SF_{ing \ i} \times I_{av \text{ U238}} \quad (E.III-14)$$

where

$ILCR_{av \text{ U238}}$ = ILCR from ingestion of vegetables contaminated by aerial deposition (r/lifetime)

$SF_{ing \ i}$ = Slope factor for ingestion of constituent "i" (r/pCi)

The linear relationship between air concentration and risk for this receptor, pathway, and radionuclide is determined by substituting the lifetime intake from fruit and vegetable consumption calculation in Equation 13 and the ingestion of slope factor for U-238 ($SF_{ing \text{ U238}} = 2.8 \times 10^{-11}$ r/pCi), for Equation E.III-14. This yields:

$$\begin{aligned} ILCR_{av \text{ U238}} &= (2.8 \times 10^{-11} \text{ r/pCi})(1,470,588 \text{ pCi/lifetime}) \\ ILCR_{av \text{ U238}} &= 4.1 \times 10^{-5} \text{ r/lifetime.} \end{aligned} \quad (E.III-15)$$

Because the exposure model used in this scenario responds linearly to changes in concentration, each additional pCi/m³ of U-238 in air is predicted to result in a calculated excess risk of 4×10^{-5} .

E.III.2.3 Ingestion of Meat or Milk Downwind of Source

Forage, feed, and soils downwind of a potential source of contaminated dust can have contamination deposited on them by settling dust. Ingestion of these plants by livestock contributes to the body burden of these contaminants in livestock. Consumption of meat or milk from these animals contributes to the total intake of these contaminants by humans.

The magnitude of the contaminant exposure by humans depends, in part, on the concentration of the constituent in the animal products. If measured values are not available (e.g. future exposures), this concentration can be calculated using the methodology set forth in the FEMP Risk Assessment Work Plan Addendum (DOE 1992a). The concentration of a contaminant in animal products, such as beef or milk, is estimated using the following equation:

$$C_{Ai} = F_{Ai} [(C_{afi})(Q_f) + (C_{agi})(Q_g) + (C_{asi})(Q_s)] e^{-\lambda_{eff} t_h} \quad (E.III-16)$$

4787

where

C_{Ai}	=	concentration of i^{th} contaminant in the animal product (pCi/mL for milk, pCi/g for beef, rad) (mg/L for milk, mg/g for beef, chem)	2
C_{afi}	=	concentration of i^{th} contaminant in feed (pCi/g, rad) (mg/kg, chem)	3
C_{agi}	=	concentration of i^{th} contaminant in forage (pCi/g, rad) (mg/kg, chem)	4
C_{asi}	=	concentration of i^{th} contaminant in soil (pCi/g, rad) (mg/kg, chem)	5
F_{Ai}	=	elemental transfer coefficient that relates the daily intake by an animal to the concentration of i^{th} contaminant in an edible portion of the animal product (d/L for milk, d/g for meat)	6
Q_f	=	consumption rate of contaminated feed by livestock (g/d, rad) (kg/d, chem)	7
Q_g	=	consumption rate of contaminated forage by livestock (g/d, rad) (kg/d, chem)	8
Q_s	=	consumption rate of contaminated soil by livestock (g/d, rad) (kg/d, chem)	9
λ_{ri}	=	radioactive or chemical decay constant of i^{th} contaminant (h^{-1})	10
t_h	=	duration of period between harvest and consumption (h)	11

Estimating the magnitude of this intake is a two step process. First, the concentration in the soil, feed, and forage is estimated. If measured values are not available (e.g. future exposures), this concentration is estimated. The amount attributable to dust deposition is calculated using Equation E.III-6. In the second step, the concentrations in animal products (meat and milk) are calculated.

Uptake of contaminants by feed and forage grown downwind of air emissions containing 1 pCi/m^3 have been selected as an example calculation for this pathway. Assuming that the mean deposition velocity for dust in the study area (V) is about 0.0018 m/s (EPA 1991), the aerial deposition rate of U-238 (d_d) per unit area calculated by Equation E.III-9 is $6.48 \text{ pCi/m}^2/\text{h}$. Assuming the plants are centered in the study area, they will always be downwind, so (f_d) is unity (1). The duration of time in which the plants and surrounding soil are exposed to aerial deposition during the study period is 1,000 years ($t_{bd} = 8,760,000 \text{ h}$). The fraction of airborne material retained on the plant surface (r_d) is 0.25. The weathering removal rate (λ_w) is 0.0021 h^{-1} . The dry soil to dry plant partitioning coefficient of U-238 in the feed and forage ($B_{iv(1)}$) is 8.5×10^{-3} . The dry plant mass to wet plant mass ratio for this case is 1.0. The effective dry surface density of the soil (ρ) is $225,000 \text{ g/m}^2$. The agricultural yield (Y) is 800 g/m^2 , and the growing season (t_g) is 3312 hours for feed and 720 hours for forage. The period between harvest and consumption (t_h) is 6160 hours for feed and 0 hours for forage. The radiological decay constant of U-238 (λ_{ri}) is $1.77 \times 10^{-14} \text{ h}^{-1}$. This value is so small that the $\exp(-\lambda_{ri} t_h)$ term approaches a value of 1 (i.e. no significant decay) for both the forage and the feed calculations. A value of 1.61×10^{-5} is calculated for $\lambda_d \text{ U238}$ using a K_d of $12 \text{ cm}^3/\text{g}$ obtained from Appendix D. Chemical degradation does not apply and is set equal to zero (0). Substituting the parameter values for forage into Equation E.III-6 and simplifying yields:

$$C_{avi} = (6.48 \text{ pCi/m}^2/\text{h}) \left[\frac{(0.25)(1 - e^{-(0.0021 \text{ h}^{-1})(720 \text{ h})})}{(800 \text{ g/m}^2)(0.0021 \text{ h}^{-1})} + \frac{(1)(0.0085)(1)(1 - e^{-(0.0000161 \text{ h}^{-1})(8760000 \text{ h})})}{(225000 \text{ g/m}^2)(0.0000161 \text{ h}^{-1})} \right] \quad (\text{E.III-17})$$

$$C_{af \text{ U238}} = 0.767 \text{ pCi/g}$$

Substituting the parameter values for feed into Equation E.III-6 and simplifying yields:

$$C_{avi} = (6.48 \text{ pCi/m}^2/\text{h}) \left[\frac{(0.25)(1 - e^{-(0.0021 \text{ h}^{-1})(3312 \text{ h})})}{(800 \text{ g/m}^2)(0.0021 \text{ h}^{-1})} + \frac{(1)(0.0085)(1)(1 - e^{-(0.0000161 \text{ h}^{-1})(8760000 \text{ h})})}{(225000 \text{ g/m}^2)(0.0000161 \text{ h}^{-1})} \right] \quad (\text{E.III-18})$$

$$C_{af \text{ U238}} = 0.979 \text{ pCi/g}$$

Cows also consume soil while grazing. Concentrations in the soil attributable to aerial deposition can be calculated by multiplying the aerial deposition rate by the second term in parentheses in Equation E.III-6. Since the medium of interest is the soil itself, and not a plant growing in the soil, the $B_{iv(2)}$ term is removed leaving:

$$C_{si} = d_d \frac{f_d(1 - e^{-\lambda_d t_h})}{\rho \lambda_d} \times e^{-\lambda_d t_h} \quad (\text{E.III-19})$$

Substituting previously-described variables in Section E.III.3 into this equation produces an estimated soil concentration of:

$$C_{si} = 6.48 \text{ pCi/m}^2/\text{h} \frac{(1)(1 - e^{-(1.61 \times 10^{-5})(8760000 \text{ h})})}{(225000 \text{ g/m}^2)(1.61 \times 10^{-5})} (1) \quad (\text{E.III-20})$$

$$C_{as \text{ U238}} = 1.78 \text{ pCi/g}$$

Once the concentrations in feed, forage, and soil have been estimated, concentrations in the animal products can be calculated using Equation E.III-16. Continuing the example begun in Equation E.III-17, the concentrations of U-238 in feed, forage, and soil attributable to dust deposition are about 0.979 pCi/g, 0.767 pCi/g, and 1.78 pCi/g, respectively. In this study, a cow is assumed to consume 25,000 g/d of stored feed (Q_f), 25,000 g/d of forage (Q_g), and 500 g/d of soil (Q_s). The food-to-beef biotransfer factor ($F_{m \text{ U238}}$) is 2.0×10^{-7} d/g and the food-to-milk biotransfer factor ($F_{d \text{ U238}}$) is 6.0×10^{-7} d/ml. The period between harvest and consumption (t_h) is 480 hours for beef and is 24 hours for

milk. The radiological decay constant of U-238 λ_{ti} is $1.77 \times 10^{-10} \text{ y}^{-1}$. This value is so small that the $\exp(-\lambda_{ti} t_h)$ term approaches a value of 1 (i.e. no significant decay) for both the beef and milk calculations. Substituting the presented parameter values for beef into Equation E.III-16 yields a meat concentration ($C_{Ai} = C_{m \text{ U238}}$) of:

$$C_{am \text{ U238}} = (2.0 \times 10^{-7} \text{ d/g})[(0.979 \text{ pCi/g})(25000 \text{ g/d}) + (0.767 \text{ pCi/g})(25000 \text{ g/d}) + (1.78 \text{ pCi/g})(500 \text{ g/d})] \quad (\text{E.III-21})$$

$$C_{am \text{ U238}} = 0.00891 \text{ pCi/g}$$

Using the presented parameter values for milk yields a U-238 concentration in milk ($C_{Ai} = C_{d \text{ U238}}$) of:

$$C_{ad \text{ U238}} = (6.0 \times 10^{-7} \text{ d/mL})[(0.979 \text{ pCi/g})(25000 \text{ g/d}) + (0.767 \text{ pCi/g})(25000 \text{ g/d}) + (1.78 \text{ pCi/g})(500 \text{ g/d})] \quad (\text{E.III-22})$$

$$C_{ad \text{ U238}} = 0.0267 \text{ pCi/mL}$$

Once the constituent's concentration in the animal product is estimated, the resulting intake by humans can be estimated using Equations 7-17 and 7-18 of the FEMP Risk Assessment Work Plan Addendum (DOE 1992a):

$$(\text{radionuclides}) \quad I_{Ai} = (C_{Ai})(IR)(FI)(EF)(ED) \quad (\text{E.III-23})$$

$$(\text{chemicals}) \quad I_{Ai} = (C_{Ai})(IR)(FI)(EF)(ED)/(BW)(AT) \quad (\text{E.III-24})$$

where

- I_{Ai} = intake of i^{th} constituent from animal product (pCi, rad) (mg/kg-d, chem)
- C_{Ai} = concentration of i^{th} contaminant in animal product (pCi/g beef or pCi/mL, rad) (mg/kg beef or mg/L milk, chem)
- IR = ingestion rate (g beef/d or mL milk/d, rad) (kg beef/d or L milk/d, chem)
- FI = fraction ingested from contaminated source (unitless)
- EF = exposure frequency (d/y)
- ED = exposure duration (y)
- BW = body weight (kg)
- AT = averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)

The calculated concentration of U-238 in beef and milk in the example scenario is about 0.00891 pCi/g and 0.0267 pCi/mL, respectively. The exposure frequency is 350 days per year ($EF = 350 \text{ d/y}$). The fraction ingested from the contaminated source ($FI \times IR$) is 75 g/d for beef and 300 mL/d for milk. The exposure duration (ED) is 70 years in days. After substituting the appropriate parameter values for beef ingestion into Equation E.III-24, the lifetime intake of U-238 from eating beef ($I_{Ai} = I_{am \text{ U238}}$) is estimated as:

0895

4787

$$I_{am\ U238} = (0.00891\ \text{pCi/g})(75\ \text{g/d})[(350\ \text{d/y})(70\ \text{y/lifetime})] \quad (\text{E.III-25})$$

$$I_{am\ U238} = 16,372\ \text{pCi/lifetime}$$

After substituting the appropriate parameter values for milk ingestion into Equation E.III-23, the lifetime intake of U-238 from consuming dairy products ($I_{Ai} = I_{ad\ U238}$) is calculated as:

$$I_{ad\ U238} = (0.0267\ \text{pCi/mL})(300\ \text{mL/d})(350\ \text{d/y})(70\ \text{y/lifetime}) \quad (\text{E.III-26})$$

$$I_{ad\ U238} = 196,245\ \text{pCi/lifetime}$$

The total intake from ingesting meat and dairy products raised on feed and forage grown in air containing U-238 ($I_{aA\ U238}$) is:

$$I_{aA\ U238} = I_{am\ U238} + I_{ad\ U238} \quad (\text{E.III-27})$$

$$I_{aA\ U238} = (16,372\ \text{pCi/lifetime}) + (196,245\ \text{pCi/lifetime})$$

$$I_{aA\ U238} = 212,617\ \text{pCi/lifetime}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they estimate that each additional pCi/m^3 of U-238 in air will produce an incremental lifetime intake of about 213,000 pCi of U-238 via these pathways.

The ILCR to this receptor for this pathway from this radionuclide is:

$$\text{ILCR}_{aA\ U238} = \text{SF}_{\text{ing } i} \times I_{aA\ U238} \quad (\text{E.III-28})$$

where

$$\text{ILCR}_{aA\ U238} = \text{ILCR from ingestion of meat or milk downwind of source (r/lifetime)}$$

$$\text{SF}_{\text{ing } i} = \text{Slope factor for ingestion of constituent "i" (r/pCi)}$$

The relationship between air concentration and risk for this receptor, pathway, and radionuclide is determined by the lifetime intake of U-238 from animal products calculated in Equation E.III-27 and substituting the ingestion slope factor for U-238, 2.8×10^{-11} r/pCi, for $\text{SF}_{\text{ing } i}$ into Equation E.IV-28. This yields:

$$\text{ILCR}_{aA\ U238} = (2.8 \times 10^{-11}\ \text{r/pCi})(212,617\ \text{pCi/lifetime}) \quad (\text{E.III-29})$$

$$\text{ILCR}_{aA\ U238} = 5.95 \times 10^{-6}\ \text{r/lifetime}$$

Because the exposure model used in this scenario responds linearly to changes in concentration, each additional pCi/m³ of U-238 in air is predicted to result in a calculated excess risk of 6×10^{-6} .

E.III.2.4 Calculation of an ILCR from a Combination of All Airborne Exposure Pathways

In some situations, a hypothetical resident both inhales air containing suspended material and ingests crops grown in areas of experiencing aerial deposition. The total risks to the same receptor from these two pathways may be calculated as:

$$ILCR_{air\ i} = (I_{ai})(SF_{inh\ i}) + (I_{avi} + I_{aAi})(SF_{ing\ i}) \quad (E.III-30)$$

where

$ILCR_{air\ i}$	=	ILCR (risk of cancer incidence/lifetime)
I_{ai}	=	intake from inhaling constituent "i" (pCi/lifetime)
I_{avi}	=	intake of constituent "i" in food crops from aerial deposition (pCi/lifetime)
I_{aAi}	=	intake of constituent "i" in animal products from aerial deposition (pCi/lifetime)
$SF_{ing\ i}$	=	Slope factor for ingestion of constituent "i" (r/pCi)
$SF_{inh\ i}$	=	Slope factor for inhalation of constituent "i" (r/pCi)

A farmer living downwind of a plume of U-238 particles has been selected as the example for this calculation. The total intake by inhalation for this hypothetical receptor for each pCi of U-238 per m³ of air is calculated in Section E.III.1. Similarly, the intake from each pCi of U-238 per m³ of air from eating vegetables and animal products grown downwind of air emissions are calculated in Sections E.III.1.2 and E.III.1.3. Substituting these values into Equation E.III-30, along with the appropriate HEAST Slope Factors of inhalation and ingestion of uranium, yields:

$$\begin{aligned}
 ILCR_{air\ U238} &= (115,910 \text{ pCi/lifetime})(5.2 \times 10^{-8} \text{ r/pCi}) \\
 &\quad + [(1,470,588 \text{ pCi/lifetime}) + (212,617 \text{ pCi/lifetime})](2.8 \times 10^{-11} \text{ r/pCi}) \quad (E.III-31) \\
 ILCR_{air\ U238} &= 6.1 \times 10^{-3} \text{ r/lifetime}
 \end{aligned}$$

The exposure model used in this scenario respond linearly to changes in concentration. Therefore each additional pCi/m³ of U-238 in air results in a calculated excess risk of 6×10^{-3} r/lifetime to the resident adult from these airborne exposures.

E.III.3 WATER EXPOSURES

The Great Miami River User Scenario is used to demonstrate the calculation of intakes and risks associated with using river water containing U-238. Examples are also included demonstrating the application of the methodology to vinyl chloride.

E.III.3.1 Drinking Water Ingestion Pathway

Ingestion of contaminated drinking water can be a major contributor to environmental intakes of a constituent of potential concern (CPC). An estimate of intake from drinking water is calculated from

4787

Equations 7-3 and 7-4 of the Risk Assessment Work Plan Addendum (DOE 1992a). The intake equations are:

$$\text{(radionuclides)} \quad I_{wi} = (C_{wi})(IR)(FI)(ED)(EF) \quad (\text{E.III-32})$$

$$\text{(chemicals)} \quad I_{wi} = (C_{wi})(IR)(FI)(ED)(EF)/(BW)(AT) \quad (\text{E.III-33})$$

where

- I_{wi} = intake of i^{th} contaminant from drinking water (pCi, rad) (mg/kg-d, chem)
- C_{wi} = i^{th} concentration in water (pCi/L, rad) (mg/L, chem)
- IR = ingestion rate (L/d)
- FI = fraction ingested from source (unitless)
- EF = exposure frequency (d/y)
- ED = exposure duration (y)
- BW = body weight (kg); and
- AT = averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y [EPA 1991c]); for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)

Ingestion of water containing U-238 by a resident adult for a 70-year lifetime is selected for the example calculation. The ingestion rate (IR) is 2 L/d. The exposure frequency is 350 days per year (EF = 350 d/y). The exposure duration (ED) is 70 years. The lifetime intake is given by Equation E.III-32, above. Using the presented parameter values, this becomes:

$$I_{w \text{ U238}} = (C_{w \text{ U238}} \text{ pCi/L})(2 \text{ L/d})(70 \text{ y})(350 \text{ d/y}) \quad (\text{E.III-34})$$

$$I_{w \text{ U238}} = (C_{w \text{ U238}} \text{ pCi/L})(49,000 \text{ L/lifetime})$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each pCi/L of U-238 in water will produce a lifetime intake of 49,000 pCi of U-238 via this one pathway.

The ILCR to this receptor for this pathway from this radionuclide is:

$$ILCR_{w \text{ U238}} = SF_{\text{ing } i} \times I_{w \text{ U238}} \quad (\text{E.III-35})$$

where

$ILCR_{w \text{ U238}}$ = ILCR from ingestion of drinking water (r/lifetime)

$SF_{\text{ing } i}$ = Slope factor for ingestion of constituent "i" (r/pCi)

4787

The relationship between water concentration and risk for this receptor, pathway, and radionuclide is determined by combining equations E.III-34 and E.III-35 and substituting the ingestion slope factor for U-238, 2.8×10^{-11} r/pCi, for $SF_{ing\ i}$. This yields:

$$\begin{aligned} ILCR_{w\ U238} &= (2.8 \times 10^{-11} \text{ r/pCi})(C_{w\ U238} \text{ pCi/L})(49000 \text{ L/lifetime}) \\ ILCR_{w\ U238} &= (C_{w\ U238} \text{ pCi/L})(1.4 \times 10^{-6} \text{ r-L/pCi-lifetime}) \end{aligned} \quad (E.III.36)$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each additional pCi/L of U-238 in water will produce an incremental lifetime cancer risk of about 1×10^{-6} via this one pathway.

E.III.3.2 Incidental Ingestion of Surface Water While Swimming

People living near bodies of water receiving contaminated runoff may accidentally ingest contaminated water while swimming. Intake from incidental ingestion of surface water while swimming is quantified using Equations E.III-32 and E.III-33.

Ingestion of surface water containing U-238 ($C_{w\ U238}$) while swimming has been selected for the example calculation. The ingestion rate (IR) is 0.05 L/h. The exposure time (ET) is 2.6 h/d, the exposure frequency is 7 days per year ($EF = 7 \text{ d/y}$), and the exposure duration (ED) is 70 years. The lifetime intake for U-238 is estimated using Equation E.III-32, above. Using the presented parameter values, this becomes:

$$\begin{aligned} I_{s\ U238} &= (C_{w\ U238} \text{ pCi/L})(0.05 \text{ L/h})(2.6 \text{ h/d})(7 \text{ d/y})(70 \text{ y}) \\ I_{s\ U238} &= (C_{w\ U238} \text{ pCi/L})64 \text{ L/lifetime} \end{aligned} \quad (E.III-37)$$

Since the exposure models used in this scenario respond linearly to changes in concentration, each pCi/L of U-238 in water will produce a lifetime intake of 64 pCi of U-238 via this one pathway.

The ILCR to this receptor for this pathway from this radionuclide is:

$$ILCR_{s\ U238} = SF_{ing\ i} \times I_{s\ U238} \quad (E.III-38)$$

where

$ILCR_{s\ U238}$ = ILCR from incidental ingestion of surface water while swimming (r/lifetime)
 $SF_{ing\ i}$ = Slope factor for ingestion of constituent "i" (r/pCi)

The relationship between water concentration and risk for this receptor, pathway, and radionuclide is determined by combining Equations E.III-37 and E.III-38 and substituting the ingestion slope factor for U-238, 2.8×10^{-11} r/pCi, for SF_{ing} . This yields:

$$ILCR_{U238} = (2.8 \times 10^{-11} \text{ r/pCi})(64 \text{ pCi/lifetime}) \quad (\text{E.III-39})$$

$$ILCR_{U238} = 1.8 \times 10^{-9} \text{ r-L/pCi-lifetime}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each additional pCi/L of U-238 in water will produce an incremental lifetime cancer risk of about 2×10^{-8} via this one pathway.

E.III.3.3 Volatiles Released by Showering and Other Household Water Uses

The amount of a chemical taken into the body via exposure to volatilization of chemicals from showering is evaluated using the concentration of a chemical in the water source. Intake from the volatilization of chemicals in household water is calculated using the Andelman model presented (EPA 1991f):

$$(\text{radionuclides}) I_{wai} = (C_{wi})(K)(IR_i)(EF)(ED) \quad (\text{E.III-40})$$

$$(\text{chemicals}) I_{wai} = (C_{wi})(K)(IR_i)(EF)(ED)/(BW)(AT) \quad (\text{E.III-41})$$

where

I_{wai}	=	intake of volatiles in water from inhalation (pCi, rad)(mg/kg-d,chem)
C_{wi}	=	concentration of constituent "i" in water (mg/L)
K	=	volatilization factor (0.5 L/m^3)
IR	=	indoor inhalation rate (m^3/d)
EF	=	exposure frequency (d/y)
ED	=	exposure duration (y)
BW	=	body weight (kg)
AT	=	averaging time (d); for carcinogens, AT equals (ED) (365 d/y [EPA 1991c]); for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)

For most metals, and hence most radionuclides in Operable Unit 1, volatilization is not a significant pathway because they do not vaporize at room temperature. The notable radioactive exceptions are the isotopes of radon. Therefore, this pathway is not quantitatively presented for uranium. An example of this pathway is presented for vinyl chloride in Section E.III.39.

E.III.3.4 Dermal Contact While Bathing

The estimation of intake of contaminants in water via absorption through the skin is determined using the concentration of a chemical in the water source evaluated. Evaluation of the dermal absorption pathway is performed for adults and children. The amount of a chemical taken into the body upon

exposure via dermal contact is referred to as an absorbed dose. The absorbed dose can be calculated using EPA's dermal guidance (EPA 1989a, EPA 1992e, and EPA 1992h):

$$I_{ws} = (DA_{event})(EV)(EF)(ED)(SA)/(BW)(AT) \quad (E.III-42)$$

where

- I_{ws} = Intake through skin from showering (mg/kg-d)
- DA_{event} = Absorbed dose per event (mg/cm²-event)
- EV = Event frequency (event/d)
- SA = Surface area (cm²)
- EF = Exposure frequency (d/y)
- ED = Exposure duration (y)
- BW = Body weight (kg)
- AT = Averaging time (for carcinogens, AT = 25550 d)

DA_{event} can be calculated as:

$$DA_{event} = (C_v)(2)(K_p)[(6)(\tau)(ET)/\pi]^{0.5} \text{ if } t_{event} < t^*, \text{ or} \quad (E.III-43)$$
$$DA_{event} = (C_v)(K_p) \{ [(t_{event})(2)(\tau)(1+3B)]/(1+B) \} \text{ if } t_{event} > t^* \quad (E.III-44)$$

where

- C_v = Concentration in the vehicle (mg/L)
- K_p = Permeability constant (cm/h)
- τ = Lag time (h)
- B = Partitioning coefficient (unitless)
- t_{event} = Time of event (h)
- π = Pi (3.14)
- t^* = Time required for steady state absorption to be reached (h)

For showering, the vehicle is domestic water, and for swimming, the vehicle is river water. In either case, C_v equals the concentration in the water (C_w). For most metals, and hence most radionuclides in Operable Unit 1, dermal absorption is not a significant pathway because penetration through the skin is minimal. See Section E.III.3.9 for an example of this pathway using methyl chloride.

E.III.3.5 Irrigation of Vegetables

Eating vegetables irrigated with contaminated water can contribute to the total intake of contaminants by humans. Estimating the magnitude of this intake is a two-step process. First the concentration in the vegetables must be estimated. In the second step, the human intake of constituent is calculated. If measured constituent concentration in plants are not available (e.g. future exposures) this concentration is estimated using Equation 7-9 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992a). The equation is:

4787

$$C_{vwi} = d_w \left[\frac{r_w(1 - e^{-\lambda_{ri}t_e})}{Y\lambda_w} + \frac{f_w B_{iv(2)} CF_p (1 - e^{-\lambda_{di}t_{bw}})}{\rho \lambda_{di}} \right] e^{-\lambda_{ri}t_h} \quad (E.III-45)$$

where

- C_{vwi} = concentration of i^{th} contaminant in plants as a result of irrigating plants with contaminated water (pCi/g, rad) (mg/kg, chem)
- λ_{di} = effective depletion constant of i^{th} contaminant from first 15 cm inches of soil. This includes radioactive decay, chemical degradation, and leaching (h^{-1}).
- λ_w = effective depletion constant of i^{th} contaminant on the surface plants also known as the weathering removal rate (h^{-1})
- λ_{ri} = radioactive or chemical decay constant of i^{th} contaminant (h^{-1})
- $B_{iv(2)}$ = dry soil to wet plant partitioning coefficient of i^{th} contaminant in food crops (C_{iv}/C_s)
- CF_p = Dry plant mass to wet plant mass ratio. (0.428 for food crops)
- d_w = irrigation deposition rate (pCi/m²-h, rad) (mg/m²-h, chem)
- f_w = fraction of year plant is irrigated (unitless)
- ρ = effective dry surface density of the soil (g/m², rad) (kg/m², chem)
- r_w = fraction of water borne material retained on plant surface (unitless)
- t_e = growing season (h)
- t_{bw} = duration of irrigation use (h)
- t_h = duration of period between harvest and consumption (h)
- Y = agricultural yield (g/m², rad) (kg/m², chem)

Vegetables irrigated with water containing U-238 (C_w U238) have been selected for the example calculation. The mean irrigation rate (d_w) per unit area is 0.081 L/m²-h, so the rate of constituent deposition by irrigation is (C_w U238 pCi/L) (0.081 L/m²-h), and the fraction of the growing season that the plant is irrigated (f_w) is 1. The duration of the study period is 1000 years ($t_{bw} = 8.76 \times 10^6$ h). The fraction of waterborne material retained on the plant surface (r_w) is 0.2. The weathering removal rate (λ_w) is 0.0021 h^{-1} . The dry soil to wet plant partitioning coefficient of U-238 in the reproductive portions of vegetables ($B_{iv(2)}$) is 4×10^{-3} . The dry plant mass to wet plant mass ratio is 0.428. The effective dry surface density of the soil is (ρ) 225,000 g/m². The agricultural yield is (Y) 1,500 g/m². The growing season t_e is 1,440 hours. The period between harvest and consumption (t_h) is 24 hours. The radiological decay constant of U-238 λ_{ri} is $1.77 \times 10^{-14} h^{-1}$. This value is so small that the $\exp(-\lambda_{ri} t_h)$ term approaches a value of 1 (i.e. no significant decay). A value of 1.61×10^{-5} is calculated for λ_{Li} using Equation E.III-8 and a Kd of 12 cm³/g from Appendix D. The effective depletion coefficient (λ_{di}) is calculated from Equation E.III-7 to be 1.61×10^{-5} . Substituting these parameter values into Equation E.III-457 and simplifying yields:

$$C_{avi} = (0.081 \text{ pCi/m}^2/\text{h}) \left[\frac{(0.2)(1 - e^{-(0.0021 \text{ h}^{-1})(1440 \text{ h})})}{(1500 \text{ g/m}^2)(0.0021 \text{ h}^{-1})} + \frac{(1)(0.004)(0.483)(1 - e^{-(1.61 \times 10^{-5} \text{ h}^{-1})(8760000 \text{ h})})}{(225000 \text{ g/m}^2)(1.61 \times 10^{-5} \text{ h}^{-1})} \right] \quad (E.III-46)$$

$$C_{vv \text{ U238}} = 0.00493 \text{ pCi/g}$$

4787

Once the constituent's concentration in the vegetables is estimated, the resulting intake by humans can be estimated using Equations E.III-11 or E.III-12. Continuing the example begun in Equation E.III-46, humans ingest vegetables from the study area for a 70-year lifetime. The calculated concentration of U-238 in vegetables and fruit is about 0.00493 pCi/g. The exposure frequency is 350 days out of per year (EF = 350 d/y). The consumption rate of vegetables and fruit grown in the study area is 122 grams per day (FI x IR). The exposure duration (ED) is 70 years per lifetime. The lifetime intake of U-238 from this food supply may be estimated by Equation E.III-11. Using the presented parameter values, this becomes:

$$I_v \text{ U238} = (0.00493 \text{ pCi/g})(122 \text{ g/d})(350 \text{ d/y})(70 \text{ y/lifetime}) \quad (\text{E.III-47})$$

$$I_v \text{ U238} = 14,736 \text{ pCi/lifetime}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, each additional pCi/L of U-238 in water will produce an incremental lifetime intake of 14,736 pCi of U-238 via this one pathway.

The ILCR to this receptor for this pathway from this radionuclide is:

$$\text{ILCR}_v \text{ U238} = \text{SF}_{\text{ing } i} \times I_v \text{ U238} \quad (\text{E.III-48})$$

where

$$\text{ILCR}_v \text{ U238} = \text{ILCR from irrigation of vegetables (r/lifetime)}$$

$$\text{SF}_{\text{ing } i} = \text{Slope factor for ingestion of constituent "i" (r/pCi)}$$

The relationship between water concentration and risk for this receptor, pathway, and radionuclide is determined by substituting the lifetime intake of U-238 eating vegetables and fruit calculated in Equation E.III-47 and the ingestion slope factor for U-238, $2.8 \times 10^{-11} \text{ r/pCi}$, for $\text{SF}_{\text{ing } i}$ into Equation E.III-48. This yields:

$$\text{ILCR}_v \text{ U238} = (2.8 \times 10^{-11} \text{ r/pCi})(14,736 \text{ pCi/lifetime}) \quad (\text{E.III-49})$$

$$\text{ILCR}_v \text{ U238} = 4.1 \times 10^{-7} \text{ r/lifetime}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each additional pCi/L of U-238 in water will produce an incremental lifetime cancer risk of about 4×10^{-7} via this one pathway.

E.III.3.6 Ingestion of Beef and Dairy Products Produced with River Water

This scenario assumes that river water is used for stock water and irrigation of feed. Animals drinking the water ingest contaminants directly. Plants irrigated with water take up constituents via root uptake and direct deposition onto exposed surfaces by irrigation water. Ingestion of these plants by livestock also contributes to the body burden of these contaminants in the animals. Humans using products from these animals can ingest the contamination contained in them as well.

The magnitude of the contaminant exposure by humans depends, in part, on the concentration of the constituent in the animal products. If measured values are not available (e.g. future exposures), this concentration can be calculated using the methodology set forth in the FEMP Risk Assessment Work Plan Addendum (DOE 1992a). The concentration of a contaminant in animal products, such as beef or milk, is estimated using the following equation:

$$C_{Ai} = F_{Ai}[(C_{fi})(Q_f) + (C_{wi})(Q_w)] e^{-\lambda_{Ti} t_h} \quad (\text{E.III-50})$$

where

C_{Ai}	= concentration of i^{th} contaminant in the animal product (pCi/mL for milk, pCi/g for beef, rad) (mg/L for milk, mg/kg for beef, chem)
C_{fi}	= concentration of i^{th} contaminant in feed (pCi/g, rad) (mg/kg, chem)
C_{wi}	= concentration of contaminant in water (pCi/L, rad) (mg/L, chem)
F_{Ai}	= element (stable) transfer coefficient that relates the daily intake by an animal to the concentration of i^{th} contaminant in an edible portion of the animal product (d/L for milk, d/g for meat)
Q_f	= consumption rate of contaminated feed by livestock (g/d, rad) (kg/d, chem)
Q_w	= consumption rate of contaminated stock water by livestock (L/d)
λ_{Ti}	= radioactive or chemical decay constant of i^{th} contaminant (h^{-1})
t_h	= duration of period between harvest and consumption (h)

If measured values for the concentrations of constituents in stored feed are not available (e.g., future exposures), this concentration is estimated using Equation 7-9 from the Risk Assessment Work Plan Addendum (DOE 1992a). The equation is:

4787
(E.III-51)

$$C_{vwi} = d_w \left[\frac{r_w(1 - e^{-\lambda_{ri}t_e})}{Y\lambda_w} + \frac{f_w CF_p B_{iv(1)}(1 - e^{-\lambda_{di}t_{bw}})}{\rho\lambda_{di}} \right] e^{-\lambda_{ri}t_h}$$

where

C_{vwi}	= concentration of i^{th} contaminant in plants as a result of irrigating plants with contaminated water (pCi/g, rad) (mg/kg, chem)	2
λ_{di}	= effective depletion constant of i^{th} contaminant in surface soils due to radioactive decay, chemical degradation, and leaching (h^{-1})	3
λ_w	= effective depletion constant of i^{th} contaminant on the surface plants also known as the weathering removal rate (h^{-1})	4
λ_{ri}	= radioactive or chemical decay constant of i^{th} contaminant (h^{-1})	5
$B_{iv(1)}$	= dry soil to wet plant partitioning coefficient of i^{th} contaminant (C_{iw}/C_s) in animal feed	6
CF_p	= Dry plant mass to wet plant mass ratio for feed and forage (1.0)	7
d_w	= irrigation deposition rate (pCi/m ² -h, rad) (mg/m ² -h, chem)	8
f_w	= fraction of year plant is irrigated (unitless)	9
ρ	= effective dry surface density of the soil (g/m ²)	10
r_w	= fraction of water borne material retained on plant surface (unitless)	11
t_e	= growing season (h)	12
t_{bw}	= duration of irrigation use (h)	13
t_h	= duration of period between harvest and consumption (h)	14
Y	= agricultural yield (g/m ²)	15

The soil depletion coefficient is calculated by using equations E.III-7 and E.III-8.

This example assumes that stored feed is irrigated with river water containing U-238. The mean irrigation rate (d_w) per unit area is 0.081 L/m²-h, so the rate of constituent deposition by irrigation is 0.081 pCi/m²-h and the fraction of the growing season the plant is irrigated (f_w) is 1. The duration of the study period (t_{bw}) is 1,000 years (8,760,000 h). The fraction of waterborne material retained on the plant surface (r_w) is 0.2. The weathering removal rate (λ_w) is 0.0021 h⁻¹. The dry soil to wet plant partitioning coefficient of U-238 in the reproductive portions of feed ($B_{iv(2)}$) is 8.5×10^{-3} . The effective dry surface density of the soil (λ) is 225,000 g/m². The agricultural yield (Y) is 800 g/m². The growing season (t_e) is 3,312 hours. The period between harvest and consumption (t_h) is 2,160 hours. The radiological decay constant (λ_{ri}) for U-238 is 1.77×10^{-14} h⁻¹. This value is so small that the $\exp(-\lambda_{ri} t_h)$ term approaches a value of 1 (i.e., no significant decay). A value of 1.61×10^{-5} h⁻¹ is calculated for λ_{di} using Equation E.III-8 and a K_d of 12 cm³/g (from Appendix D). Substituting these parameter values into Equation E.III-51 and simplifying yields:

$$C_{wvU238} = (0.081 \text{ pCi/m}^2/\text{h}) \left[\frac{(0.2)(1 - e^{-(0.0021 \text{ h}^{-1})(3312 \text{ h})})}{(800 \text{ g/m}^2)(0.0021 \text{ h}^{-1})} + \frac{(1)(0.0085)(1)(1 - e^{-(0.0000161 \text{ h}^{-1})(8760000 \text{ h})})}{(225000 \text{ g/m}^2)(0.0000161 \text{ h}^{-1})} \right]$$

(E.III-52)

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$$C_{wmU238} = 0.00982 \text{ pCi/g}$$

Once the concentration in stored feed has been estimated, its contribution to constituent levels in beef and dairy products can be calculated using Equation E.III-50. Continuing the example begun in Equation E.III-53, the calculated concentration of U-238 in stored feed attributable to irrigation is about 9.82×10^{-3} pCi/g. In this study, a cow is assumed to consume 25,000 g/d of potentially contaminated feed (Q_f). The plant to beef and plant to milk biotransfer factors for U-238 in cows are 2×10^{-7} d/g ($F_m U_{238}$) and 6×10^{-7} d/mL ($F_d U_{238}$), respectively. The time between harvesting and consumption of stored feed is 2160 hours. The radiological decay constant of U-238 λ_{r1} is 1.77×10^{-14} h⁻¹. This value is so small that the $\exp(-\lambda_{r1} t_h)$ term approaches a value of 1 (i.e. no significant decay) for both meat and milk calculations. Beef cows ingest about 50 L/d of water (Q_{Aw}), while milk cows ingest about 60 L/d.

Substituting parameter values for the beef ingestion scenario in Equation E.III-50 ($C_{Ai} = C_{wm U238}$) yields the concentration of U-238 in beef:

$$C_{wm U238} = (2.0 \times 10^{-7} \text{ d/g})[(25000 \text{ g/d})(9.82 \times 10^{-3} \text{ pCi/g}) + (50 \text{ L/d})(1 \text{ pCi/L})] \quad (\text{E.III-53})$$

$$C_{wm U238} = 5.91 \times 10^{-5} \text{ pCi/g}$$

Substituting parameter values for the milk ingestion scenario in Equation E.III-50 ($C_{Ai} = C_{wd U238}$) yields. The concentration of U-238 in milk:

$$C_{wd U238} = (6.0 \times 10^{-7} \text{ d/mL})[(25000 \text{ g/d})(9.82 \times 10^{-3} \text{ pCi/g}) + (60 \text{ L/d})(1 \text{ pCi/L})] \quad (\text{E.III-54})$$

$$C_{wd U238} = 1.83 \times 10^{-4} \text{ pCi/mL}$$

Once the constituent's concentration in the animal product is estimated, the resulting intake by humans can be estimated using Equations E.III-23 and E.III-24. Continuing the example calculation, the farmer ingests beef containing 5.91×10^{-5} pCi/g of U-238 ($C_{wm U238}$ in Equation E.III-53) and dairy products containing 1.83×10^{-4} pCi/mL of U-238 ($C_{wd U238}$ in Equation E.III-54) for each pCi/L of U-238 in water during a 70-year lifetime. The exposure frequency is 350 days per year ($EF = 350 \text{ d/y}$). The fractions of beef and dairy products ingested from the contaminated source ($FI \times IR$) are 75 g/d and 300 mL/d, respectively. The exposure duration (ED) is 70 years. The lifetime intake of U-238 from this supply of animal products is given by Equation E.III-23. Substituting the selected parameter values for the beef ingestion scenario, this becomes:

$$I_{wm U238} = (5.91 \times 10^{-5} \text{ pCi/g})(75 \text{ g/d})(350 \text{ d/y})(70 \text{ y/lifetime}) \quad (\text{E.III-55})$$

$$I_{wm U238} = 109 \text{ pCi/lifetime}$$

Substituting the selected parameter values for the dairy products ingestion scenario, this becomes:

$$I_{wd \text{ U238}} = (1.83 \times 10^{-4} \text{ pCi/mL})(300 \text{ mL/d})(350 \text{ d/y})(70 \text{ y/lifetime}) \quad (\text{E.III-56})$$

$$I_{wd \text{ U238}} = 1345 \text{ pCi/lifetime}$$

4787

Because the exposure models used in this scenario respond linearly to changes in concentration, each pCi/L of U-238 in water will produce an incremental lifetime intake of 109 pCi U-238 via the beef ingestion pathway and 1345 pCi of U-238 via the milk ingestion pathway.

The ILCR to this receptor for these pathways from this radionuclide is:

$$ILCR_{m \text{ U238}} = SF_{ing \ i} \times I_{m \text{ U238}} \text{ (beef)}$$

or

$$ILCR_{d \text{ U238}} = SF_{ing \ i} \times I_{d \text{ U238}} \text{ (dairy)} \quad (\text{E.III-57})$$

where

$ILCR_{m \text{ U238}}$ or $ILCR_{d \text{ U238}} =$ ILCR from ingestion of beef or dairy products produced with river water (r/lifetime)

$SF_{ing \ i} =$ Slope factor for ingestion of constituent "i" (r/pCi)

The relationship between air concentration and risk for this receptor, pathway, and radionuclide is determined by substituting the lifetime intake of U-238 calculated in Equations E.III-55 and E.III-56 and the ingestion slope factor for U-238, 2.8×10^{-11} r/pCi, for $SF_{ing \ i}$ into Equation E.III-57. This yields:

Beef:

$$ILCR_{m \text{ U238}} = (2.8 \times 10^{-11} \text{ r/pCi})(109 \text{ pCi/lifetime}) \quad (\text{E.III-58})$$

$$ILCR_{m \text{ U238}} = 3.1 \times 10^{-9} \text{ r/lifetime}$$

Dairy:

$$ILCR_{d \text{ U238}} = (2.8 \times 10^{-11} \text{ r/pCi})(1345 \text{ pCi/lifetime}) \quad (\text{E.III-59})$$

$$ILCR_{d \text{ U238}} = 3.8 \times 10^{-8} \text{ r/lifetime}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each additional pCi/L of U-238 in water will produce an incremental lifetime cancer risk of about 3×10^{-9} via the beef pathway, and 4×10^{-8} via the milk pathway.

E.III.3.7 Ingestion of Fish

If measured concentrations of a constituent in fish are unknown, they are estimated using Equation 7-19 of the FEMP Risk Assessment Work Plan Addendum (DOE 1992a):

4787

$$C_{Fi} = (C_{wi})(BCF_{Fi}) e^{-\lambda_{ri} t_h} \quad (\text{E.III-60})$$

where

C_{Fi}	=	concentration of the i^{th} constituent in fish (pCi/kg, rad) (mg/kg, chem)
C_{wi}	=	concentration of the i^{th} constituent in surface water (pCi/L, rad) (mg/L, chem)
BCF_{Fi}	=	fish bioconcentration factor (pCi/g fish per pCi/L, rad) (mg/kg fish per mg/L, chem)
λ_{ri}	=	radioactive or chemical decay constant of i^{th} contaminant (h^{-1})
t_h	=	duration of period between harvest and consumption (h)

Fish in water containing U-238 have been selected for the example calculation. The biotransfer factor from water to fish ($BCF_{F \text{ U238}}$) is 0.002 L/g (USNRC 1984)). The period between harvest and consumption (t_h) is 24 hours. The radiological decay constant of U-238 (λ_{ri}) is $1.77 \times 10^{-14} \text{ h}^{-1}$. This value is so small that the $\exp(-\lambda_{ri} t_h)$ term approaches a value of 1 (i.e. no significant decay).

Substituting these parameter values into Equation E.III-60 produces:

$$C_{F \text{ U238}} = (1 \text{ pCi/L})(0.002 \text{ L/g})(1) \quad (\text{E.III-61})$$

$$C_{F \text{ U238}} = 0.002 \text{ pCi/g}$$

Once the concentration in fish has been estimated, intake can be calculated as:

$$(\text{radionuclides}) I_{Fi} = (C_{Fi})(IR)(FI)(ED)(EF) \quad (\text{E.III-62})$$

$$(\text{chemicals}) I_{Fi} = (C_{Fi})(IR)(FI)(ED)(EF)/(BW)(AT) \quad (\text{E.III-63})$$

where

I_{Fi}	=	intake of i^{th} constituent from fish ingestion (pCi, rad) (mg/kg-d, chem)
C_{Fi}	=	concentration of i^{th} constituent in fish (pCi/g, rad) (mg/kg, chem)
IR	=	ingestion rate (g/d, rad) (kg/g, chem)
FI	=	fraction ingested from contaminated source (unitless)
EF	=	exposure frequency (d/y)
ED	=	exposure duration (y)
BW	=	body weight (kg)
AT	=	averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)

Continuing the previous example, it is assumed that a recreational fisherman ingests 54 grams of fish per day ($IR \times FI$) from the study area for 70 years (ED). The exposure frequency (EF) is 350 d/y. The concentration of U-238 in fish from Equation E.III-61 is 0.002 pCi/g. Substituting these parameters into Equation E.III-62 yields:

$$I_{F\ U238} = (0.002\ \text{pCi/g})(54\ \text{g/d})(350\ \text{d/y})\ (70\ \text{y/lifetime}) \quad (\text{E.III-64}) \quad 1$$
$$I_{F\ U238} = 2,646\ \text{pCi/lifetime} \quad 2$$

Because the exposure models used in this scenario respond linearly to changes in concentration, each additional pCi/L of U-238 present in water will produce an incremental lifetime intake of 2,646 pCi of U-238 via this one pathway. 3
4
5

The ILCR to this receptor for this pathway from this radionuclide is: 6

$$ILCR_{F\ U238} = SF_{\text{ing } i} \times I_{F\ U238} \quad (\text{E.III-65}) \quad 7$$

where 8

$$ILCR_{F\ U238} = \text{ILCR from ingestion of fish (r/lifetime)} \quad 9$$
$$SF_{\text{ing } i} = \text{Slope factor for ingestion of constituent "i" (r/pCi)} \quad 10$$

The risk for this receptor, pathway, and radionuclide is determined by substituting the lifetime intake calculated in Equation E.III-64 and the ingestion slope factor for U-238, 2.8×10^{-11} r/pCi, for $SF_{\text{ing } i}$ into Equation E.III-65. This yields: 11
12
13

$$ILCR_{F\ U238} = (2.8 \times 10^{-11}\ \text{r/pCi})(C_{w\ U238}\ \text{pCi/L})(2646\ \text{L/lifetime}) \quad (\text{E.III-66}) \quad 14$$
$$ILCR_{F\ U238} = 7.4 \times 10^{-8}\ \text{r/lifetime} \quad 15$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each additional pCi/L of U-238 in water will produce an incremental lifetime cancer risk of about 7×10^{-8} via this pathway. 16
17
18

E.III.3.8 Calculation of ILCR for Great Miami River User Scenario 19

In this scenario, a hypothetical farmer uses river water for drinking, domestic uses, irrigation, stock water, and recreation (fishing and swimming). The total risks to the same receptor from these exposure pathways may be calculated as: 20
21
22

$$ILCR_{\text{water } i} = (I_{wi} + I_{wvi} + I_{wmi} + I_{wdi} + I_{wsi} + I_{wFi} + I_{wbi} + I_{wsia}) \times SF_{\text{ing } i} + (I_{wgi} \times SF_{\text{inh } i}) \quad (\text{E.III-67}) \quad 23$$
$$\quad 24$$

where 25

$$ILCR_{\text{water } i} = \text{incremental Lifetime Cancer Risk (risk of cancer incidence/lifetime)} \quad 26$$
$$I_{wi} = \text{intake from drinking water (pCi/lifetime)} \quad 27$$
$$I_{wvi} = \text{intake from ingesting vegetables and fruit (pCi/lifetime)} \quad 28$$

I_{wmi}	=	intake from ingesting meat (pCi/lifetime)	1
I_{wdi}	=	intake from ingesting dairy products (pCi/lifetime)	2
I_{wsi}	=	intake from incidental ingestion while swimming (pCi/lifetime)	3
I_{wFi}	=	intake from eating fish (pCi/lifetime)	4
I_{wbi}	=	intake from absorption while bathing (pCi/lifetime)	5
I_{wsia}	=	intake from absorption while swimming (pCi/lifetime)	6
I_{wgi}	=	intake from inhalation while bathing (pCi/lifetime)	7
$SF_{ing\ i}$	=	HEAST slope factor for ingestion of constituent i (r/pCi)	8
$SF_{inh\ i}$	=	HEAST slope factor for inhalation of constituent i (r/pCi)	9

A farmer living adjacent to the Great Miami River has been selected as the example for this calculation. The total intake for this hypothetical receptor for each pCi/L of U-238 in water from these pathways have been calculated in Sections E.III.3.1 through E.III.3.8. Substituting these values into Equation E.III-67, along with the appropriate HEAST slope factors for ingestion and inhalation of uranium, yields:

$$\begin{aligned}
 ILCR_{water\ U238} &= \{[(49000\text{ pCi/lifetime}) + (64\text{ pCi/lifetime}) + (14736\text{ pCi/lifetime}) \\
 &\quad + (109\text{ pCi/lifetime}) + (1345\text{ pCi/lifetime}) \\
 &\quad + (2646\text{ pCi/lifetime})] \times 2.8 \times 10^{-11}\text{ r-pCi}\} \quad (E.III-68) \\
 ILCR_{water\ U238} &= 1.9 \times 10^{-6}\text{ r-/lifetime)}
 \end{aligned}$$

The exposure models used in this combined pathway scenario respond linearly to changes in concentration. Therefore, each additional pCi/L of U-238 present in Great Miami River water will produce an incremental lifetime cancer risk of about 2×10^{-6} r-pCi/L-lifetime from the water pathways investigated.

E.III.3.9 Risk Calculations for Vinyl Chloride in Water

An additional example has been prepared to demonstrate the application of the methodology to vinyl chloride exposures to the resident farmer from the drinking water, dermal contact, and volatilization pathways. The example ends with the calculation of one aggregate risk, which combines the exposures from these three pathways.

Drinking Water

The equation used to estimate intake from drinking water is adapted from EPA guidance (EPA 1989a).

$$I_{wd} = (C_w)(IR_o)(EF)(FI)/(BW)(AT) \quad (E.III-69)$$

where

I_{wd}	=	Intake from drinking water (mg/kg-d)	32
C_w	=	Concentration in water (mg/L)	33
IR_o	=	Ingestion rate (2 L/d)	34
EF	=	Exposure frequency (350 d/y)	35
ED	=	Exposure duration (70 y)	36

4787

FI = Fraction ingested from the contaminated source (1)
BW = Body weight (70 kg)
AT = Averaging time (for carcinogens, AT = 25,550 d)

The relationship of concentration to intake for this receptor, pathway, and chemical is determined by substituting the constants listed above into Equation E.III.69:

$$\begin{aligned} I_{wd} &= (1 \text{ mg/L})(2 \text{ L/d})(70 \text{ y})(350 \text{ d/y})(1)/[(70 \text{ kg})(25,550 \text{ d})] \\ I_{wd} &= 0.027 \text{ mg/kg-d} \end{aligned} \quad (\text{E.III-70})$$

Incremental lifetime risk to this receptor, for this pathway, from this chemical is:

$$ILCR_d = SF_o \times I_{wd} \quad (\text{E.III-71})$$

where

$ILCR_d$ = Incremental lifetime cancer risk from drinking water (unitless)
 I_{wd} = Intake from drinking water (mg/kg-d)
 SF_o = Slope factor (1.9 r-k-g-d/mg-lifetime)

The risk for this receptor, pathway, and chemical is determined by substituting the lifetime intake calculated in Equation E.III-70 and vinyl chloride's oral slope factor (1.9 r-k-g-d/mg-lifetime) for SF_o into Equation E.III-71. This yields:

$$\begin{aligned} ILCR_d &= (1.9 \text{ r-k-g-d/mg-lifetime})(0.027 \text{ mg/kg-d}) \\ ILCR_d &= 0.051 \text{ r/Lifetime} \end{aligned} \quad (\text{E.III-72})$$

Thus, each additional mg/L of vinyl chloride in water will yield a calculated excess risk of 5×10^{-2} for this receptor and pathway.

Volatilization

Intake from volatilization of chemicals in household water is calculated using the Andelman model (EPA 1991b).

$$I_{wa} = (C_w)(K)(IR_i)(EF)(ED)/(BW)(AT) \quad (\text{E.III-73})$$

where

I_{wa} = Intake from inhaling chemicals volatilized from water to air (mg/kg-d)
 C_w = Concentration in water (mg/L)
 K = Volatilization factor (0.5 L/m³)
 IR_i = Inhalation rate (15 m³/d)
 EF = Exposure frequency (350 d/y)
 ED = Exposure duration (70 y)
 BW = Body weight (70 kg)
 AT = Averaging time (for carcinogens, AT = 25,550 d)

The intake for this receptor, pathway, and chemical is determined by substituting the constants listed above into Equation III-73:

$$I_{wa} = (1 \text{ mg/L})(0.5 \text{ L/m}^3\text{/d})(15 \text{ m}^3\text{/d})(350 \text{ d/y})(70 \text{ y})/(70 \text{ kg})(25,550 \text{ d})$$

$$I_{wa} = 0.10 \text{ mg/kg-d} \quad (\text{E.III-74})$$

The Incremental Lifetime Cancer Risk to this receptor, for this pathway, from this chemical is:

$$\text{ILCR}_v = \text{SF}_i \times I_{wa} \quad (\text{E.III-75})$$

where

$$\begin{aligned} \text{ILCR}_v &= \text{Incremental lifetime cancer risk from volatilization (unitless)} \\ I_{wa} &= \text{Intake from drinking water (mg/kg-d)} \\ \text{SF}_i &= \text{Slope factor (0.3 r-kg-d/mg-lifetime)} \end{aligned}$$

The risk for this receptor, pathway, and chemical is determined by substituting the lifetime intake calculated by Equation E.III-74 and the inhalation slope factor of vinyl chloride for SF_i into Equation E.III-75. This yields:

$$\begin{aligned} \text{ILCR}_v &= (0.3 \text{ r-kg-d/mg-lifetime})(0.10 \text{ mg/d-kg}) \\ \text{ILCR}_v &= 0.030 \text{ r/lifetime} \end{aligned} \quad (\text{E.III-76})$$

Thus, each additional mg/L of vinyl chloride in water will yield a calculated excess risk of 3×10^{-2} r/lifetime for this receptor and pathway.

Dermal Contact:

Intake from dermal contact with household water containing vinyl chloride is calculated using the EPA's dermal guidance (EPA 1989a, 1992b, 1992c):

$$I_{ws} = (\text{DA}_{\text{event}})(\text{EV})(\text{EF})(\text{ED})(\text{CF})(\text{SA})/(\text{BW})(\text{AT}) \quad (\text{E.III-77})$$

where

$$\begin{aligned} I_{ws} &= \text{Intake through skin from showering or bathing (mg/kg-d)} \\ \text{DA}_{\text{event}} &= \text{Absorbed dose per event (mg/cm}^2\text{-event)} \\ \text{EV} &= \text{Event frequency (event/d)} \\ \text{SA} &= \text{Surface area (cm}^2\text{)} \\ \text{EF} &= \text{Exposure frequency (d/y)} \\ \text{ED} &= \text{Exposure duration (y)} \\ \text{CF} &= \text{Conversion factor (0.001 L/cm}^3\text{)} \\ \text{BW} &= \text{Body weight (kg)} \\ \text{AT} &= \text{Averaging time (for carcinogens, AT = 25,550 d)} \end{aligned}$$

DA_{event} can be calculated as:

$$DA_{event} = (C_w)(2)(K_p)[(6)(TAO)(t_{event})/\pi]^{0.5} \text{ if } t_{event} < t^*, \text{ or}$$

$$DA_{event} = (C_w)(K_p)\{[(t_{event})+(2)(TAO)(1+3B)]/(1+B)\} \text{ if } t_{event} > t^*$$

4787

where

- C_w = Concentration in water (mg/L)
 K_p = Permeability constant (0.0073 cm/h)
 TAO = Lag time (0.21 h)
 B = Partitioning coefficient (unitless)
 t_{event} = Time of event (0.25 h)
 π = Pi (3.14)
 t^* = Time to steady state conditions (0.5)

For showering, the vehicle is domestic water, and for swimming the vehicle is river water. In either case, C_w equals concentration in the water (C_w).

The intake for this receptor, pathway, and chemical is determined by substituting the constants listed above into Equation E.III-77:

$$I_{ws} = (1 \text{ mg/L})(2)(0.0073 \text{ cm/h})[(6)(0.21 \text{ h})(0.25 \text{ h})/(3.14)]^{0.5}$$

$$\times (1 \text{ event/d})(350 \text{ d/y})(70 \text{ y})(20,000 \text{ cm}^2)(0.001 \text{ L/cm}^3)/(70 \text{ kg})(25,550 \text{ d})$$

$$I_{ws} = 0.00127 \text{ mg/kg-d} \quad (\text{E.III-78})$$

Incremental lifetime risk to this receptor, for this pathway, from this chemical is:

$$ILCR_s = SF_s \times I_{ws} \quad (\text{E.III-79})$$

where

- $ILCR_s$ = Incremental lifetime cancer risk from dermal exposures (unitless)
 I_{ws} = Intake through skin from showering or bathing (mg/kg-d)
 SF_s = Dermal slope factor (1.9 r-k-g-d/mg-lifetime)

SF_s is derived by dividing the oral slope factor (1.9 r-k-g-d/mg-lifetime) by the GI absorption factor for vinyl chloride (0.9), yielding a value for SF_s of 2.1 r-k-g-d/mg-lifetime. The relationship between intake and risk for this receptor, pathway, and chemical is determined by combining Equations E.III-78 and E.III-79 and substituting the dermal slope factor of vinyl chloride for SF_s . This yields:

$$ILCR_s = (2.1 \text{ r-k-g-d/mg-lifetime})(0.013 \text{ mg/kg-d}) \quad (\text{E.III-80})$$

$$ILCR_s = 0.0027 \text{ r/lifetime}$$

Thus, each mg/L of vinyl chloride in water will yield a calculated excess risk of about 3×10^{-3} for this receptor and pathway.

Equations E.III-70, E.III-74, and E.III-78 may be used to calculate the incremental lifetime risk of cancer incidence to a resident adult from exposures related to drinking water, inhalation of volatiles from household water, or dermal contact with water for a given concentration of vinyl chloride in water. The risks from these pathways are additive to a receptor experiencing more than one of them. The combined risks from all three of these pathways ($ILCR_t$) is calculated by adding these risks together:

$$\begin{aligned} ILCR_t &= ILCR_d + ILCR_v + ILCR_g & (E.III-81) \\ ILCR_t &= (0.051 \text{ r/lifetime}) + (0.030 \text{ r/lifetime}) + (0.0027 \text{ r/lifetime}) \\ ILCR_t &= 0.084 \text{ r/lifetime} \end{aligned}$$

The calculated excess risk to the resident adult from each additional pCi/L of vinyl chloride in water from these three pathways is calculated to be about 3×10^{-3} r/lifetime.

E.III.4 SOIL AND SEDIMENT EXPOSURES

The on-property resident RME is used to illustrate the calculation of risks associated with U238 in soil.

E.III.4.1 Incidental Ingestion of Soil or Sediment

Evaluation of the soil/sediment ingestion pathway is performed using Equations 7-7 and 7-8 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992a):

$$(\text{radionuclides}) \quad I_{si} = (C_{si})(IR)(ED)(EF)(FI) \quad (E.III-82)$$

$$(\text{chemicals}) \quad I_{si} = (C_{si})(IR)(CF)(FI)(EF)(ED)/(BW)(AT) \quad (E.III-83)$$

where

I_{si}	=	intake from soil or sediment for constituent i (pCi, rad) (mg/kg-d, chem)
C_{si}	=	concentration of constituent i in soil or sediment (pCi/g, rad) (mg/kg, chem)
IR	=	ingestion rate (g/d, rad) (kg/d, chem)
CF	=	conversion factor 10^{-6} kg/mg
FI	=	fraction ingested from contaminated source (unitless)
EF	=	exposure frequency (d/y)
ED	=	exposure duration (y)
BW	=	body weight (kg)
AT	=	averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)

Incidental ingestion of soil by the hypothetical on-property receptor has been selected to illustrate how intakes via the soil ingestion pathway are estimated. The time weighted average annual ingestion rate of soil over a 70 year lifetime from the study area ($IR \times FI$) is about 0.18 g/d. The exposure

frequency is 350 days per year ($EF = 350$ d/y), and the exposure duration (ED) is 70 y/lifetime.

Substituting these parameter values into Equation E.III-82 yields:

$$I_{s, U238} = (1 \text{ pCi/g})(0.18 \text{ g/d})(350 \text{ d/y})(70 \text{ y/lifetime}) \quad (\text{E.III-84})$$

$$I_{s, U238} = 4,410 \text{ pCi/lifetime}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they estimate that each additional pCi/g of U-238 in soil will produce an incremental lifetime intake of about 4,410 pCi of U-238 via this pathway.

The ILCR to this receptor for this pathway from this radionuclide is:

$$ILCR_{s, U238} = SF_{ing, i} \times I_{s, U238} \quad (\text{E.III-85})$$

where

$ILCR_{s, U238}$ = ILCR from incidental ingestion of soil or sediment (r/lifetime)

$SF_{ing, i}$ = Slope factor for ingestion of constituent "i" (r/pCi)

The risk for this receptor, pathway, and radionuclide is determined by substituting the lifetime intake of U-238 calculated in Equation E.III-84 and the ingestion slope factor for U-238, 2.8×10^{-11} r/pCi, for $SF_{ing, i}$ into Equation E.III-85. This yields:

$$ILCR_{s, U238} = (2.8 \times 10^{-11} \text{ r/pCi})(4,410/\text{lifetime}) \quad (\text{E.III-86})$$

$$ILCR_{s, U238} = (C_{s, U238} \text{ pCi/g})(1.2 \times 10^{-7} \text{ r-g/pCi-lifetime})$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each additional pCi/g of U-238 in soil will produce an incremental lifetime cancer risk of about 1×10^{-7} via this pathway.

E.III.4.2 Dermal Contact with Soil or Sediment

Dermal absorption may also occur upon contact with contaminated soil and sediment and is calculated using Equation 7-23 of the FEMP Risk Assessment Work Plan Addendum (DOE 1992a):

$$AB_{si} = (C_{si})(CF)(SA)(AF)(ABS)(ED)(EF)/(BW)(AT) \quad (\text{E.III-87})$$

where

AB_{si} = amount of i^{th} constituent absorbed during contact with soil or sediment (mg/kg-d)

C_{si}	=	concentration of i^{th} constituent in soil or sediment (mg/kg)	1
SA	=	skin surface area available for contact ($cm^2/event$)	2
AF	=	skin adherence factor (mg/cm^2)	3
ABS	=	absorption factor (unitless)	4
CF	=	conversion factor; (10^{-6} kg/mg)	5
ED	=	exposure duration (y)	6
EF	=	exposure frequency (event/y)	7
BW	=	body weight (kg)	8
AT	=	averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for chemical carcinogens, AT equals (70 y/lifetime) (365 d/y)	9 10

For most metals, dermal absorption is not a significant pathway because penetration through the skin is minimal. These example calculations are being performed for U-238, a metal. Hence, exposures via this pathway are not quantitatively presented for this example.

E.III.4.3 Ingestion of Vegetables Grown in Contaminated Soil

Plants grown in contaminated soil take up contaminants via root uptake. Ingestion of these plants by humans contributes to the total intake of contaminants by humans. Estimating the magnitude of this intake is a two step process. First, concentrations in the plants are estimated. Human intake of constituents in vegetables is then estimated in the second step. If measured plant concentrations are not available (e.g. future exposures), concentrations in the plants are estimated using Equation 7-11 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992a). The equation is:

$$C_{svi} = (C_{si})B_{iv(2)}CF_p e^{-\lambda_{ri}t_h} \quad (E.III-88)$$

where

C_{svi}	=	concentration of i^{th} contaminant in food crops (pCi/g, rad) (mg/kg, chem)	22
C_{si}	=	concentration of i^{th} contaminant in soil (pCi/g, rad) (mg/kg, chem)	23
$B_{iv(2)}$	=	dry soil to dry plant partitioning coefficient of i^{th} contaminant in food crops (C_{iv}/C_s)	24 25
CF_p	=	dry plant mass to wet plant mass ratio (unitless)	26
λ_{ri}	=	radioactive or chemical decay constant of i^{th} contaminant (h^{-1})	27
t_h	=	duration of period between harvest and consumption (h)	28

Vegetable and fruits grown in soil containing U-238 are selected to illustrate how contaminant concentrations in plants can be estimated from contaminant concentrations in soil. The dry soil to dry plant partitioning coefficient of U-238 in the reproductive portions of vegetables and fruits ($B_{iv(2)}$) is 4×10^{-3} . The dry plant mass to wet plant mass ratio is 0.428 (Baes and Sharp, 1984). The period between harvest and consumption (t_h) for vegetables is 24 hours, and 720 hours for fruit. The radiological decay constant of U-238 (λ_{ri}) is $1.77 \times 10^{-14} y^{-1}$. This value is so small that the $\exp(-\lambda_{ri} t_h)$ term approaches a value of 1 (i.e. no significant decay). Substituting these parameter values into Equation E.III-88 and simplifying yields:

0916

$$C_{sv \text{ U238}} = (1 \text{ pCi/g}_{\text{soil}})(0.428)(4 \times 10^{-3} \text{ g}_{\text{soil}}/\text{g}_{\text{plant}})(1)$$

$$C_{sv \text{ U238}} = 1.71 \times 10^{-3} \text{ pCi/g}_{\text{plant}}$$

4787

Once the concentration in crops has been estimated, the quantity ingested by the on-property resident can be calculated using Equations E.III-11 or E.III-12. Continuing the previous example, the calculated concentration of U-238 in crops ($C_{sv \text{ U238}}$ in Equation E.III-89) is calculated to be 1.93 pCi/g. The exposure frequency is 350 days per year ($EF = 350 \text{ d/y}$). The consumption rate of vegetables and fruit grown in the study area is 122 grams per day ($FI \times IR$). The exposure duration (ED) is 70 years. Substituting these parameter values into Equation E.III-11 and solving produces a lifetime ingestion via vegetables ($I_{sv \text{ U238}}$) of:

$$I_{sv \text{ U238}} = (0.00171 \text{ pCi/g}_{\text{plant}})(122 \text{ g}_{\text{plant}}/\text{d})(70 \text{ y/lifetime})(350 \text{ d/y}) \quad (\text{E.III-90})$$

$$I_{sv \text{ U238}} = 5,111 \text{ pCi/lifetime}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they estimate that each additional pCi/L of U-238 in water will produce an incremental lifetime intake of 5,111 pCi of U-238 via this pathway.

The ILCR to this receptor for this pathway from this radionuclide is:

$$\text{ILCR}_{sv \text{ U238}} = SF_{\text{ing } i} \times I_{sv \text{ U238}} \quad (\text{E.III-91})$$

where

$\text{ILCR}_{sv \text{ U238}} = \text{ILCR from ingestion of vegetables grown in contaminated soil (r/lifetime)}$

$SF_{\text{ing } i} = \text{Slope factor for ingestion of constituent "i" (r/pCi)}$

The risk for this receptor, pathway, and radionuclide is determined by substituting the lifetime intake of U-238 from eating vegetable and fruit calculated in Equation E.III-90 and the ingestion slope factor for U-238, $2.8 \times 10^{-11} \text{ r/pCi}$, for $SF_{\text{ing } i}$ into Equation E.III-91. This yields:

$$\text{ILCR}_{sv \text{ U238}} = (2.8 \times 10^{-11} \text{ r/pCi})(5,111 \text{ pCi/lifetime}) \quad (\text{E.III-92})$$

$$\text{ILCR}_{sv \text{ U238}} = 1.3 \times 10^{-7} \text{ r/lifetime}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, they predict that each additional pCi/g of U-238 in soil will produce an incremental lifetime cancer risk of about 1×10^{-7} via this pathway.

E.III.4.4 Ingestion of Meat or Milk

This scenario assumes that livestock is raised on contaminated soil. Feed and forage grown on contaminated soils take up constituents via root uptake. Ingestion of these plants by livestock contributes to the body burden of these contaminants in the animals. In addition to intake from contaminated feed and forage, cows may receive a significant intake from soil ingestion if the soil is also a source of contamination (Zach and Mayoh 1984). Humans using products from these animals can be exposed to the contamination contained in them.

The magnitude of the contaminant exposure by humans depends, in part, on the concentration of the constituent in the animal products. If measured values are not available (e.g. future exposures) this concentration can be calculated using the methodology set forth in the FEMP Risk Assessment Work Plan Addendum (DOE 1992a). The concentration of a contaminant in animal products, such as beef or milk, is estimated using the following equation:

$$C_{Ai} = F_{Ai}[(C_{fi})(Q_f) + (C_{gi})(Q_g) + (C_{si})(Q_s)] e^{-\lambda_i t_h} \quad (\text{E.III-93})$$

where

- C_{Ai} = concentration of i^{th} contaminant in the animal product, (pCi/L for milk, pCi/g for beef, rad) (mg/L for milk, mg/kg for beef, chem)
- C_{si} = concentration of contaminant in soil (pCi/g, rad) (mg/kg, chem)
- C_{gi} = concentration of i^{th} contaminant in forage (pCi/g, rad) (mg/kg, chem)
- C_{fi} = concentration of i^{th} contaminant in feed (pCi/g, rad) (mg/kg, chem)
- F_{Ai} = element (stable) transfer coefficient that relates the daily intake by an animal to the concentration of i^{th} contaminant in an edible portion of the animal product (d/L for milk, d/g for beef) (d/L for milk, d/kg for beef)
- Q_g = consumption rate of contaminated forage (pasture grass) (g/d, rad) (kg/d, chem)
- Q_s = consumption rate of soil by livestock (g/d, rad) (kg/d, chem)
- Q_f = consumption rate of contaminated feed by an animal (g/d, rad) (kg/d, chem)
- λ_i = radioactive or chemical decay constant of i^{th} contaminant (h^{-1})
- t_h = duration of period between harvest and consumption (h)

If measured values for feed and forage are not available (e.g. future exposures), the concentration in these plants that is attributable to direct uptake from soil is estimated using Equation 7-11 from the FEMP Risk Assessment Work Plan Addendum (DOE 1992a). The equation is:

$$C_{s(p)i} = (C_{si}) B_{iv(1)} CF_p e^{-\lambda_i t_h} \quad (\text{E.III-94})$$

where

- $C_{s(p)i}$ = concentration of i^{th} contaminant in the plant, where $p = g$ is forage, and $p = f$ is stored feed (pCi/g, rad) (mg/kg, chem)
- C_{si} = concentration of i^{th} contaminant in soil (pCi/g, rad) (mg/kg, chem)
- $B_{iv(1)}$ = dry soil to dry plant partitioning coefficient of i^{th} contaminant in forage (C_{sg}/C_{si})
- CF_p = dry plant mass to wet plant mass ratio (unitless)

October 12, 1993

λ_{ri} = radioactive or chemical decay constant of i^{th} contaminant (h^{-1})
 t_h = duration of period between harvest and consumption (h)

4287

The concentration of U-238 in plants grown in soil U-238 ($C_{s(p) \text{ U238}}$) has been selected to illustrate how contaminant concentrations in feed and forage can be estimated from contaminant concentrations in soil. The dry soil to wet plant partitioning coefficient of U-238 in feed and forage ($B_{iv(1)}$) is $8.5 \times 10^{-3} \text{ g}_{\text{soil}}/\text{g}_{\text{plant}}$. The periods between harvest and consumption (t_h) of forage and stored feed are 0 hours and 2160 hours, respectively. The radiological decay constant of U-238 λ_{ri} is $1.77 \times 10^{-14} \text{ h}^{-1}$. This value is so small that the $\exp(-\lambda_{ri} t_h)$ term approaches a value of 1 (i.e. no significant decay) for both feed and forage calculations. Substituting these parameter values into Equation E.III-88 yields:

$$C_{s(g) \text{ U238}} = C_{s(f) \text{ U238}} = (1 \text{ pCi/g}_{\text{soil}})(8.5 \times 10^{-3} \text{ g}_{\text{soil}}/\text{g}_{\text{plant}})(1) \quad (\text{E.III-95})$$

$$C_{s(g) \text{ U238}} = C_{s(f) \text{ U238}} = 8.5 \times 10^{-3} \text{ pCi/g}_{\text{plant}}$$

Once the concentration in vegetation has been estimated, concentrations in the animal product can be calculated using Equation E.III-93. Continuing the example begun in Equation E.III-94, the calculated concentration of U-238 in feed and forage attributable to soil uptake ($C_{sf \text{ U238}}$ and $C_{sg \text{ U238}}$ in Equation E.III-88) is about $8.5 \times 10^{-3} \text{ pCi/g}_{\text{plant}}$. The dry plant mass to wet plant mass ratio is 1.0. In this study, cows consume 25,000 g/d of potentially contaminated forage (Q_g), 25,000 g/d of potentially contaminated feed (Q_f), and 500 g/d of potentially contaminated soil (Q_s). The plant to beef and plant to milk biotransfer factors for U-238 in cows are $2.0 \times 10^{-7} \text{ d/g}$ (F_{mi}) and $6.0 \times 10^{-7} \text{ d/mL}$ (F_{di}), respectively. The times between harvesting and consumption (t_h) of meat and milk are 24 hours and 480 hours, respectively. The radiological decay constant of U-238 λ_r is $1.77 \times 10^{-14} \text{ h}^{-1}$. This value is so small that the $\exp(-\lambda_{ri} t_h)$ term approaches a value of 1 (i.e. no significant decay) for both meat and milk calculations.

Substituting the parameter values presented for the beef cattle scenario in Equation E.III-93 yields a meat concentration ($C_{sm \text{ U238}}$) of:

$$C_{sm \text{ U238}} = (2.0 \times 10^{-7} \text{ d/g}_{\text{meat}})[(8.5 \times 10^{-3} \text{ pCi/g}_{\text{plant}})(25000 \text{ g}_{\text{plant}}/\text{d}) + (8.5 \times 10^{-3} \text{ pCi/g}_{\text{plant}})(25000 \text{ g}_{\text{plant}}/\text{d}) + (1 \text{ pCi/g}_{\text{soil}})(500 \text{ g}_{\text{soil}}/\text{d})] \quad (\text{E.III-96})$$

$$C_{sm \text{ U238}} = 0.000185 \text{ pCi/g}_{\text{meat}}$$

Substituting the parameter values presented for the dairy scenario in Equation E.III-93 yields a milk concentration ($C_{sd \text{ U238}}$) of:

$$C_{sd \text{ U238}} = (6.0 \times 10^{-7} \text{ d/mL}_{\text{milk}})[(8.5 \times 10^{-3} \text{ pCi/g}_{\text{plant}})(25000 \text{ g}_{\text{plant}}/\text{d}) + (8.5 \times 10^{-3} \text{ pCi/g}_{\text{plant}})(25000 \text{ g}_{\text{plant}}/\text{d}) + 1 \text{ pCi/g}_{\text{soil}}(500 \text{ g}_{\text{soil}}/\text{d})] \quad (\text{E.III-97})$$

$$C_{sd \text{ U238}} = 0.000555 \text{ pCi/mL}_{\text{milk}}$$

Once the concentrations of U-238 in animal products are known, the magnitude of intake by the on-property resident can be estimated. The farmer ingests beef containing 0.000185 pCi/g_{meat} of U-238 (C_{sm U238} in Equation E.III-96) and dairy products containing 0.000555 pCi/mL_{milk} pCi/g of U-238 (C_{sd U238} in Equation E.III-97) for each pCi/g of U-238 in soil over a 70 year lifetime. The exposure frequency is 350 days per year (EF = 350 d/y). The fraction ingested from the contaminated source (FI x IR) is 75 g/d for beef, and 300 mL/d for dairy products. The exposure duration (ED) is 25,550 days. The lifetime intake of U-238 from this meat supply is calculated using Equation E.III-23.

Substituting the appropriate parameter values for the beef ingestion scenario produces a lifetime ingestion via meat (I_{sm U238}) of:

$$I_{sm U238} = (0.000185 \text{ pCi/g}_{\text{meat}})(75 \text{ g}_{\text{meat}}/\text{d})(350 \text{ d/y})(70 \text{ y/lifetime}) \quad (\text{E.III-98})$$

$$I_{sm U238} = 340 \text{ pCi/lifetime}$$

Substituting the appropriate parameter values for the dairy product ingestion scenario produces a lifetime ingestion via dairy products (I_{sd U238}) of:

$$I_{sd U238} = (0.000555 \text{ pCi/mL}_{\text{milk}})(300 \text{ mL}_{\text{milk}}/\text{d})(350 \text{ d/y})(70 \text{ y/lifetime}) \quad (\text{E.III-99})$$

$$I_{sd U238} = (4079 \text{ pCi/lifetime})$$

Because the exposure models used in this scenario respond linearly to changes in concentration, each additional pCi/g of U-238 in soil will produce an incremental lifetime intake of 340 pCi of U-238 via the beef ingestion pathway and an intake of 4079 pCi of U-238 via the dairy ingestion pathway.

The ILCR to this receptor for this pathway from this radionuclide is:

$$ILCR_{m U238} = SF_{ing i} \times I_{m U238} \text{ (beef)}$$

or

$$ILCR_{d U238} = SF_{ing i} \times I_{d U238} \text{ (dairy)} \quad (\text{E.III-100})$$

where

$$ILCR_{m U238} \text{ or } ILCR_{d U238} = ILCR \text{ from ingestion of beef or dairy products (r/lifetime)}$$

$$SF_{ing i} = \text{Slope factor for ingestion of constituent "i" (r/pCi)}$$

The relationship between soil concentration and risk for this receptor, pathway, and radionuclide is determined by substituting the lifetime intake of U-238 from consuming beef and dairy products

calculated by Equations E.III-98 and E.III-99 and the U_{238} ingestion slope factor, 2.8×10^{-11} r/pCi, for SF_{ing} into Equation E.III-100. This yields:

Beef:

$$ILCR_{m U238} = (2.8 \times 10^{-11} \text{ r/pCi})(340 \text{ pCi/lifetime}) \quad (\text{E-III.101})$$

$$ILCR_{m U238} = 9.5 \times 10^{-9} \text{ r-g/pCi-lifetime}$$

Dairy:

$$ILCR_{d U238} = (2.8 \times 10^{-11} \text{ r/pCi})(4079 \text{ pCi/lifetime}) \quad (\text{E-III.102})$$

$$ILCR_{d U238} = 1.1 \times 10^{-7} \text{ r-g/pCi-lifetime}$$

The exposure models used in this scenario respond linearly to changes in concentration. Therefore, each additional pCi/g of U-238 in soil will produce an incremental lifetime cancer risk of about 1×10^{-8} via the beef pathway, and 1×10^{-7} via the milk pathway.

E.III.4.5 Direct Radiation Exposure

Since the publication of the Risk Assessment Work Plan Addendum, EPA has published a new set of slope factors. Changes in these slope factors require the use of a different equation to calculate risks resulting from external radiation exposures from soils than the one originally presented in the Risk Assessment Work Plan Addendum. The new equation is:

$$ILCR_e = SF_{ext} \times C_s \times ED \times EF \times CF \times [ET_{in} \times (1-S_i) + ET_{out} \times (1-S_o)] \quad (\text{E.III-103})$$

where

$ILCR_e$ = Incremental Lifetime Cancer Risk (ILCR/lifetime)

C_s = concentration in surface soil (pCi/g)

SF_{ext} = HEAST Slope Factor (ILCR - g/pCi -y)

ED = exposure duration (y/lifetime)

EF = exposure frequency (d/y)

ET_{in} = exposure time indoors on-site (h/d)

ET_{out} = exposure time outdoors on-site (h/d)

S_i = indoor shielding factor (0.5, from Risk Assessment Work Plan Addendum)

S_o = outdoor shielding factor outdoors (0, assumes no shielding)

CF = 1/8760 y/h

The risk to an on-property resident RME directly attributable to U-238 in soil is the example calculation. In this calculation, exposure duration (ED) is 70 years, and the exposure frequency is 350 days per year ($EF = 350$ d/y). The exposure time for outdoor activities assumes the resident is outdoors 2000 hours out of a 350 day year ($ET_{out} = 2000 \text{ h}/350 \text{ d}$). The exposure time for indoor activities is the remainder of the time available ($ET_{in} = 24 \text{ h/d} - ET_{out}$). The value for the indoor

shielding factor (S_i) is 0.5, and the value for the outdoor shielding factor (S_o) is 0. Substituting these parameters into Equation E.III-103 yields:

$$ILCR_e = (SF_o)(1 \text{ pCi/g})(70\text{y/lifetime})(350\text{d/y})(\text{y}/8760 \text{ h}) \times [(18.3 \text{ h/d})(1-0.5) + (5.7 \text{ h/d})(1-0.0)] \quad (\text{E.III-104})$$

$$ILCR_e = 1.50 \times 10^{-6} \text{ r/Lifetime}$$

Because the exposure models used in this scenario respond linearly to changes in concentration, each additional pCi/g of U-238 in soil will increase the source strength by 41.5 pCi-y/g-life and the risks by $1.50 \times 10^{-6} \text{ r/Lifetime}$ via the direct exposure pathway.

E.III.4.6 Calculation of Aggregate Risks For On-Property Resident from All Soil Pathways

In this scenario, a hypothetical resident ingests contaminated dirt, and crops, beef, and milk grown in or on contaminated soil. The receptor also receives exposures from direct dermal contact and direct irradiation. The total risks to the on-property resident RME exposed to soil from these pathways may be calculated as:

$$ILCR_{\text{soil } i} = (I_{s i} + I_{sv i} + I_{sm i} + I_{sd i} + I_{sa i}) \times SF_{\text{ing } i} + ILCR_e i \quad (\text{E.III-105})$$

where

- $ILCR_{\text{soil } i}$ = incremental Lifetime Cancer Risk (risk of cancer incidence/lifetime);
- $ILCR_e i$ = incremental Lifetime Cancer Risk from direct radiation (risk of cancer incidence/lifetime).
- $I_{s i}$ = unit intake from soil (pCi/lifetime);
- $I_{sv i}$ = unit intake from ingesting vegetables and fruit (pCi/lifetime);
- $I_{sm i}$ = unit intake from ingesting meat (pCi/lifetime);
- $I_{sd i}$ = unit intake from ingesting dairy products (pCi/lifetime);
- $I_{sa i}$ = unit intake from absorption during dermal contact (pCi/lifetime); and
- $SF_{\text{ing } i}$ = HEAST slope factor for ingestion of constituent i (r/pCi).

The intake by this hypothetical receptor for each pCi/L of U-238 in soil from each of these pathways has been calculated in Sections E.III.4.1 through E.III.4.4. The ILCR from external exposure to direct radiation is presented in Section E.III.4.5. Substituting these values into Equation E.III-93, along with the appropriate HEAST Slope Factors for ingestion and inhalation of uranium, yields:

$$\begin{aligned} ILCR_{\text{soil U23}} &= \{[(4,410 \text{ pCi/lifetime}) + (11,956 \text{ pCi/lifetime}) + (340 \text{ pCi/lifetime}) \\ &+ (4,079 \text{ g/lifetime})] \times 2.8 \times 10^{-11} \text{ r/pCi}\} \\ &+ [(41.5 \text{ pCi-y/g-life})(3.6 \times 10^{-8} \text{ r-g/y-pCi})] \end{aligned} \quad (\text{E.III-106})$$

$$ILCR_{\text{soil U238}} = (C_{\text{U238}} \text{ pCi/g})(1.9 \times 10^{-6} \text{ r-g/pCi-lifetime})$$

1

The exposure models used in this scenario respond linearly to changes in concentration. Therefore, each additional pCi/g of U-238 in soil will produce an incremental lifetime cancer risk of about 2×10^{-6} r-g/pCi-lifetime to the RME resident farmer soil from all direct exposure pathways investigated.

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TABLE E.III-1

PARAMETERS USED IN EXPOSURE PATHWAY MODELS

Constituent	K_d	λ_{L1}	λ_{L2}	Water - Fish F_{fi}	Soil - Forage $B_{v(1)}$	Soil - Crop $B_{v(2)}$	Plant - Beef F_{bi}	Plant - Meat F_{mi}
Radionuclide	mL/g	(hr ⁻¹)	(hr ⁻¹)	(L/g)	(unitless)	(unitless)	(d/g)	(d/mL)
Am-241	8.40×10^3	2.33×10^{-8}	1.83×10^{-7}	2.5×10^{-1}	5.5×10^{-3}	2.4×10^{-4}	3.5×10^{-9}	2.0×10^{-8}
Cs-137 + 1 dtr	1.81×10^3	1.08×10^{-7}	2.62×10^{-6}	2.0×10^0	8.0×10^{-2}	3.0×10^{-2}	2.0×10^{-5}	4.0×10^{-6}
Np-237 + 1 dtr	5.50×10^1	3.55×10^{-6}	3.70×10^{-11}	1.0×10^{-2}	1.0×10^{-1}	1.0×10^{-2}	5.5×10^{-8}	7.0×10^{-6}
Pb-210 + 2 dtrs	3.00×10^3	6.52×10^{-8}	3.55×10^{-6}	1.0×10^{-1}	4.5×10^{-2}	9.0×10^{-3}	3.0×10^{-7}	5.0×10^{-9}
Pu-238	1.70×10^3	1.15×10^{-7}	9.02×10^{-7}	2.5×10^{-2}	4.5×10^{-4}	4.5×10^{-5}	5.0×10^{-10}	5.0×10^{-9}
Pu-239/240	1.70×10^3	1.15×10^{-7}	3.28×10^{-9}	2.5×10^{-2}	4.5×10^{-4}	4.5×10^{-5}	5.0×10^{-10}	2.5×10^{-7}
Ra-226 + 5 dtrs	6.96×10^2	2.81×10^{-7}	4.95×10^{-8}	5.0×10^{-2}	1.5×10^{-2}	1.5×10^{-3}	2.5×10^{-7}	1.0×10^{-10}
Ra-228 + 1 dtr	6.96×10^2	2.81×10^{-7}	1.38×10^{-5}	5.0×10^{-2}	1.5×10^{-2}	1.5×10^{-3}	2.5×10^{-7}	1.0×10^{-10}
Ru-106 + Rh-106	8.00×10^2	2.44×10^{-7}	7.84×10^{-5}	1.0×10^{-2}	7.5×10^{-2}	2.0×10^{-2}	2.0×10^{-6}	4.5×10^{-7}
Sr-90 + 1 dtr	1.00×10^1	1.93×10^{-5}	2.77×10^{-6}	3.0×10^{-2}	2.5×10^0	2.5×10^{-1}	3.0×10^{-7}	4.5×10^{-7}
Tc-99	1.18×10^{-1}	8.45×10^{-4}	3.71×10^{-10}	1.5×10^{-2}	9.5×10^0	1.5×10^0	8.5×10^{-6}	6.0×10^{-10}
Th-228 + 7 dtrs	5.80×10^3	3.37×10^{-8}	4.14×10^{-5}	3.0×10^{-2}	8.5×10^{-4}	8.5×10^{-5}	6.0×10^{-9}	1.5×10^{-6}
Th-230	5.80×10^3	3.37×10^{-8}	1.03×10^{-9}	3.0×10^{-2}	8.5×10^{-4}	8.5×10^{-5}	6.0×10^{-9}	1.0×10^{-5}
Th-232	5.80×10^3	3.37×10^{-8}	5.63×10^{-15}	3.0×10^{-2}	8.5×10^{-4}	8.5×10^{-5}	6.0×10^{-9}	5.0×10^{-9}
Th-232 + 10 dtrs	5.80×10^0	3.37×10^{-8}	5.63×10^{-15}	3.0×10^{-2}	8.5×10^{-4}	8.5×10^{-5}	6.0×10^{-9}	5.0×10^{-9}
U-233	1.2×10^1	1.61×10^{-5}	4.97×10^{-10}	2.0×10^{-3}	8.5×10^{-3}	4.0×10^{-3}	2.0×10^{-7}	5.0×10^{-9}
U-234	1.2×10^1	1.61×10^{-5}	3.24×10^{-10}	2.0×10^{-3}	8.5×10^{-3}	4.0×10^{-3}	2.0×10^{-7}	5.0×10^{-9}
U-235 + 1 dtr	1.2×10^1	1.61×10^{-5}	1.12×10^{-13}	2.0×10^{-3}	8.5×10^{-3}	4.0×10^{-3}	2.0×10^{-7}	6.0×10^{-7}
U-238 + 2 dtrs	1.2×10^1	1.61×10^{-5}	1.77×10^{-14}	2.0×10^{-3}	8.5×10^{-3}	4.0×10^{-3}	2.0×10^{-7}	6.0×10^{-7}

*NUREG/CR-35985

^bBaes and Sharp, 1984

TABLE E.III-1
(Continued)

Constituent	K_d	λ_{ui}	λ_{hi}	Water - Fish F_n	Soil - Forage $B_{vi(1)}$	Soil - Crop $B_{vi(2)}$	Plant - Beef F_{bi}	Plant - Meat F_{mi}
Inorganic Chemical	mL/g	(hr ⁻¹)	(hr ⁻¹)	(L/kg)	(unitless)	(unitless)	(d/kg)	(d/L)
Antimony	2.5×10^{-2}	1.2×10^{-7}	0.0×10^0	1.0×10^0	2.0×10^{-1}	3.0×10^{-2}	1.0×10^{-3}	1.0×10^{-4}
Arsenic	2.0×10^2	1.5×10^{-7}	0.0×10^0	4.4×10^1	4.0×10^{-2}	6.0×10^{-3}	2.0×10^{-3}	6.0×10^{-5}
Barium	1.1×10^3	2.6×10^{-8}	0.0×10^0	NA	1.5×10^{-1}	1.5×10^{-2}	1.5×10^{-4}	3.5×10^{-4}
Beryllium	1.3×10^3	2.3×10^{-8}	0.0×10^0	1.9×10^1	1.0×10^{-2}	1.5×10^{-3}	1.0×10^{-3}	9.0×10^{-7}
Boron	3.0×10^0	9.3×10^{-6}	0.0×10^0	NA	4.0×10^0	2.0×10^0	8.0×10^{-4}	1.5×10^{-3}
Cadmium	5.1×10^2	5.9×10^{-8}	0.0×10^0	8.1×10^1	5.5×10^{-1}	1.5×10^{-1}	5.5×10^{-4}	1.0×10^{-3}
Chromium	1.5×10^3	2.0×10^{-8}	0.0×10^0	1.6×10^1	7.5×10^{-3}	4.5×10^{-3}	5.5×10^{-3}	1.5×10^{-3}
Cobalt	5.5×10^2	5.4×10^{-8}	0.0×10^0	NA	2.0×10^{-2}	7.0×10^{-3}	2.0×10^{-2}	2.0×10^{-3}
Copper	1.3×10^2	2.4×10^{-7}	0.0×10^0	2.0×10^2	4.0×10^{-1}	2.5×10^{-1}	1.0×10^{-2}	1.5×10^{-3}
Cyanide	NA	NA	0.0×10^0	0.0×10^0	2.4×10^1	2.4×10^1	5.6×10^{-8}	1.8×10^{-8}
Lead	3.0×10^3	9.9×10^{-9}	0.0×10^0	4.9×10^1	4.5×10^{-2}	9.0×10^{-3}	3.0×10^{-4}	2.5×10^{-4}
Manganese	1.8×10^2	1.6×10^{-7}	0.0×10^0	NA	2.5×10^{-1}	5.0×10^{-2}	4.0×10^{-4}	3.5×10^{-4}
Mercury	1.0×10^1	2.9×10^{-6}	0.0×10^0	5.5×10^3	9.0×10^{-1}	2.0×10^{-1}	2.5×10^{-1}	4.5×10^{-4}
Molybdenum	9.0×10^1	3.3×10^{-7}	0.0×10^0	NA	2.5×10^{-1}	6.0×10^{-2}	6.0×10^{-3}	1.5×10^{-3}
Nickel	6.5×10^2	4.6×10^{-8}	0.0×10^0	4.7×10^1	6.0×10^{-2}	6.0×10^{-2}	6.0×10^{-3}	1.0×10^{-3}
Selenium	7.4×10^2	4.0×10^{-8}	0.0×10^0	1.6×10^1	2.5×10^{-2}	2.5×10^{-2}	1.5×10^{-2}	4.0×10^{-3}
Silver	1.8×10^2	1.6×10^{-7}	0.0×10^0	3.1×10^3	4.0×10^{-1}	1.0×10^{-1}	3.0×10^{-3}	2.0×10^{-2}
Thallium	1.5×10^3	2.0×10^{-8}	0.0×10^0	NA	4.0×10^{-3}	4.0×10^{-4}	4.0×10^{-2}	2.0×10^{-3}
Tin	2.5×10^2	1.2×10^{-7}	0.0×10^0	3.0×10^3	3.0×10^{-2}	6.0×10^{-3}	8.0×10^{-2}	1.0×10^{-3}
Uranium	1.2×10^1	6.6×10^{-8}	0.0×10^0	NA	8.5×10^{-3}	4.0×10^{-3}	2.0×10^{-4}	6.0×10^{-4}
Vanadium	1.0×10^3	3.0×10^{-8}	0.0×10^0	NA	5.5×10^{-3}	3.0×10^{-3}	2.5×10^{-3}	2.0×10^{-5}
Zinc	2.4×10^3	1.2×10^{-8}	0.0×10^0	4.7×10^1	1.5×10^0	9.0×10^{-1}	1.0×10^{-1}	1.0×10^{-2}

E-III-39

0925

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TABLE E.III-1
(Continued)

Constituent	K_d	λ_L	λ_H	Water - Fish F_H	Soil - Forage $B_{vi(1)}$	Soil - Crop $B_{vi(2)}$	Plant - Beef F_{bi}	Plant - Meat F_{mi}
Organic Chemical	mL/g	(hr ⁻¹)	(hr ⁻¹)	(L/kg)	(unitless)	(unitless)	(d/kg)	(d/L)
1,2,3,7,8-Pentachlorodibenzofuran	1.8×10^6	1.6×10^{-11}	2.6×10^{-4}	NA	1.5×10^{-1}	1.5×10^{-1}	2.8×10^{-1}	1.4×10^{-1}
2,3,4,7,8-Pentachlorodibenzofuran	1.8×10^6	1.6×10^{-11}	2.6×10^{-4}	NA	1.5×10^{-1}	1.5×10^{-1}	2.8×10^{-1}	1.4×10^{-1}
2,3,7,8-Tetrachlorodibenzofuran	1.8×10^6	1.6×10^{-11}	2.6×10^{-4}	NA	1.5×10^{-1}	1.5×10^{-1}	2.8×10^{-1}	1.4×10^{-1}
2,4,5-Trichlorophenol	1.0×10^2	2.9×10^{-7}	1.6×10^{-5}	4.0×10^2	2.7×10^{-1}	2.7×10^{-1}	1.3×10^{-4}	4.2×10^{-5}
2-Methylnaphthalene	1.4×10^2	2.1×10^{-7}	NA	5.1×10^2	2.3×10^{-1}	2.3×10^{-1}	1.8×10^{-4}	5.8×10^{-5}
4,4-DDT	3.0×10^4	1.0×10^{-9}	5.0×10^{-6}	5.4×10^4	1.6×10^{-2}	1.6×10^{-2}	2.8×10^{-2}	2.4×10^{-3}
4-Nitroaniline	4.7×10^{-1}	4.4×10^{-5}	NA	6.8×10^0	6.1×10^0	6.1×10^0	6.3×10^{-7}	2.0×10^{-7}
4-Nitrophenol	1.6×10^0	1.7×10^{-5}	2.9×10^{-3}	1.6×10^1	3.1×10^0	3.1×10^0	2.0×10^{-6}	6.5×10^{-7}
Acenaphthene	1.6×10^2	1.9×10^{-7}	7.1×10^{-5}	2.4×10^2	2.1×10^{-1}	2.1×10^{-1}	2.1×10^{-4}	6.6×10^{-5}
Acenaphthylene	2.3×10^2	1.3×10^{-7}	1.2×10^{-4}	7.3×10^2	1.7×10^{-1}	1.7×10^{-1}	3.0×10^{-4}	9.3×10^{-5}
Anthracene	5.4×10^2	5.5×10^{-8}	1.6×10^{-5}	1.4×10^3	2.7×10^{-2}	2.7×10^{-2}	7.1×10^{-4}	2.2×10^{-4}
Aroclor-1016	4.6×10^2	6.4×10^{-8}	NA	1.0×10^5	1.1×10^{-1}	1.1×10^{-1}	6.0×10^{-4}	1.9×10^{-4}
Aroclor-1221	2.4×10^2	1.3×10^{-7}	NA	1.0×10^5	1.7×10^{-1}	1.7×10^{-1}	3.1×10^{-4}	9.8×10^{-5}
Aroclor-1242	2.5×10^2	1.2×10^{-7}	NA	7.8×10^2	1.6×10^{-1}	1.6×10^{-1}	3.2×10^{-4}	1.0×10^{-4}
Aroclor-1248	1.1×10^4	2.7×10^{-9}	NA	7.1×10^4	1.8×10^{-2}	1.8×10^{-2}	1.4×10^{-2}	4.5×10^{-3}
Aroclor-1254	2.1×10^4	1.4×10^{-9}	NA	1.0×10^5	1.7×10^{-2}	1.7×10^{-2}	5.3×10^{-2}	1.1×10^{-2}
Aroclor-1260	2.5×10^4	1.2×10^{-9}	NA	1.9×10^5	1.1×10^{-2}	1.1×10^{-2}	3.2×10^{-2}	1.0×10^{-2}
Benzene	2.6×10^0	1.1×10^{-5}	4.0×10^{-5}	5.2×10^0	2.3×10^0	2.3×10^0	3.4×10^{-6}	1.1×10^{-6}
Benzo(a)anthracene	7.7×10^3	3.9×10^{-9}	1.0×10^{-5}	1.1×10^4	2.2×10^{-2}	2.2×10^{-2}	1.0×10^{-2}	3.2×10^{-3}
Benzo(a)pyrene	1.8×10^4	1.6×10^{-9}	1.0×10^{-5}	2.1×10^4	5.6×10^{-2}	5.6×10^{-2}	2.4×10^{-2}	7.6×10^{-3}
Benzo(b)fluoranthene	7.1×10^4	4.2×10^{-10}	1.2×10^{-5}	5.8×10^4	6.2×10^{-3}	6.2×10^{-3}	9.3×10^{-2}	3.0×10^{-2}
Benzo(ghi)perylene	3.3×10^5	9.1×10^{-11}	1.1×10^{-5}	1.8×10^5	2.6×10^{-3}	2.6×10^{-3}	4.3×10^{-1}	1.4×10^{-1}
Benzo(k)fluoranthene	1.3×10^5	2.2×10^{-10}	3.3×10^{-6}	9.3×10^4	4.3×10^{-3}	4.3×10^{-3}	1.7×10^{-1}	5.5×10^{-2}

TABLE E.III-1
(Continued)

Constituent	K_d	λ_L	λ_H	Water - Fish F_n	Soil - Forage $B_{vi(1)}$	Soil - Crop $B_{vi(2)}$	Plant - Beef F_{bi}	Plant - Meat F_{mi}
Organic Chemical	mL/g	(hr ⁻¹)	(hr ⁻¹)	(L/kg)	(unitless)	(unitless)	(d/kg)	(d/L)
Chrysene	7.7×10^3	3.9×10^9	7.1×10^6	1.1×10^4	2.2×10^{-2}	2.2×10^{-2}	1.0×10^{-2}	3.2×10^{-3}
Dibenzo(a,h)anthracene	1.8×10^4	1.7×10^9	7.5×10^6	2.0×10^4	1.4×10^{-2}	1.4×10^{-2}	2.3×10^{-2}	7.4×10^{-3}
Dichlorodifluoromethane	2.8×10^0	1.0×10^5	4.0×10^5	2.6×10^1	2.2×10^0	2.2×10^0	3.6×10^{-6}	1.2×10^{-6}
Fluoranthene	4.1×10^3	7.3×10^9	1.6×10^5	1.2×10^3	3.2×10^{-2}	3.2×10^{-2}	5.4×10^{-3}	1.7×10^{-3}
Fluorene	2.9×10^2	1.0×10^7	1.2×10^4	1.3×10^3	1.5×10^{-1}	1.5×10^{-1}	3.8×10^{-4}	1.2×10^{-4}
Heptachlorodibenzo-p-dioxin	8.4×10^4	3.5×10^{10}	2.6×10^4	NA	1.5×10^{-1}	1.5×10^{-1}	2.8×10^{-1}	1.4×10^{-1}
Heptachlorodibenzofuran	1.8×10^6	1.6×10^{11}	2.6×10^4	NA	1.5×10^{-1}	1.5×10^{-1}	2.8×10^{-1}	1.4×10^{-1}
Hexachlorodibenzo-p-dioxin	8.4×10^4	3.5×10^{10}	2.6×10^4	NA	1.5×10^{-1}	1.5×10^{-1}	2.8×10^{-1}	1.4×10^{-1}
Hexachlorodibenzofuran	1.8×10^6	1.6×10^{11}	2.6×10^4	NA	1.5×10^{-1}	1.5×10^{-1}	2.8×10^{-1}	1.4×10^{-1}
Indeno(1,2,3-cd)pyrene	8.8×10^5	3.4×10^{11}	1.0×10^5	3.9×10^5	1.5×10^{-3}	1.5×10^{-3}	1.2×10^0	3.6×10^{-1}
Naphthalene	4.4×10^1	6.7×10^7	1.1×10^4	4.3×10^2	4.4×10^{-1}	4.4×10^{-1}	5.8×10^{-5}	2.0×10^{-4}
Octachlorodibenzo-p-dioxin	8.4×10^4	3.5×10^{10}	2.6×10^4	NA	1.5×10^{-1}	1.5×10^{-1}	2.8×10^{-1}	1.4×10^{-1}
Octachlorodibenzofuran	1.8×10^6	1.6×10^{11}	2.6×10^4	NA	1.5×10^{-1}	1.5×10^{-1}	2.8×10^{-1}	1.4×10^{-1}
Pentachlorophenol	2.0×10^3	1.5×10^8	1.9×10^5	7.7×10^2	4.9×10^{-2}	4.9×10^{-2}	2.6×10^{-3}	8.1×10^{-4}
Phenanthrene	5.6×10^2	5.3×10^8	3.6×10^5	2.6×10^3	1.0×10^{-1}	1.0×10^{-1}	7.2×10^{-4}	2.3×10^{-4}
Pyrene	2.9×10^3	1.0×10^8	3.8×10^6	1.4×10^0	5.6×10^0	5.6×10^0	7.2×10^{-7}	2.3×10^{-7}
Tetrachloroethene	6.5×10^0	4.4×10^6	1.8×10^5	3.1×10^1	1.3×10^0	1.3×10^0	8.5×10^{-6}	2.7×10^{-6}
Tributyl Phosphate	1.9×10^2	1.5×10^7	1.6×10^5	6.5×10^2	1.9×10^{-1}	1.9×10^{-1}	2.5×10^{-4}	7.9×10^{-5}
Vinyl Chloride	7.6×10^2	1.1×10^4	1.0×10^5	1.7×10^0	1.7×10^1	1.7×10^1	1.0×10^{-7}	3.2×10^{-8}

*Appendix D for radionuclides and inorganic chemicals. For organics, calculate K_d from K_{ow} . K_{ow} s found in EPA, WERL Database, Rev. 2.

^bCalculated from K_d . Methodology presented in "Risk Assessment Work Plan Addendum," DOE 1992.

^cRefer to *Handbook of Environmental Degradation Rates*, Howard, et al., 1991, Lewis Publishers, Inc.

^dFor inorganics, refer to *DeMinimus Waste Impacts Analysis Methodology*, NUREG/CR-3585, 1984. For organics, $\log BCF = 0.76 \log K_{ow} - 0.23$, Lyman, et al., 1982.

TABLE E.III-1
(Continued)

^aFor inorganics, refer to Baes & Sharp, 1984. For organics, $\text{Log } F_{bi} = -7.6 + \text{Log } K_{ow}$, Travis & Arms, 1988.
^bFor inorganics, refer to Baes & Sharp, 1984. For organics, $\text{Log } F_{mi} = 08.1 + \text{Log } K_{ow}$, Travis & Arms, 1988.
^cFor inorganics, refer to Baes & Sharp, 1984. For organics, $\text{Log } = 1.588 - 0.578 \text{ Log } K_{ow}$, Travis & Arms, 1988.
^dFor inorganics, refer to Baes & Sharp, 1984. For organics, $B_{vi(1)}$ assumed equal to $B_{vi(2)}$.

Legend:

K_d - Water/Soil Partitioning Coefficient (mL/g)
 λ_{LJ} - Leaching Coefficient (h-1)
 λ_{rj} - Chemical or Radioactive Decay Coefficient (h-1)
 F_f - Bioconcentration Factor for Fish (L/kg)
 F_{bi} - Biotransfer Factor for Beef (day/kg)
 F_{mi} - Biotransfer Factor for Milk (day/kg)
 $B_{vi(2)}$ - Soil-Forage Transfer Factor
 $B_{vi(1)}$ - Soil-Crop Transfer Factor

E-III-42

0928

4782

TABLE E.III-2
INTAKES - RADIONUCLIDES (pCi)^a
CURRENT CONDITIONS - AIR
TRESPASSING CHILD UNDER CURRENT LAND
USE WITHOUT ACCESS CONTROLS

Radionuclide	Concentration (pCi/m ³)	Inhalation
Cs-137 + 1 dtr	2.9×10^{-4}	6.0×10^{-1}
Np-237 + 1 dtr	1.4×10^{-4}	2.9×10^{-1}
Pu-238	1.1×10^{-4}	2.3×10^{-1}
Pu-239/240	3.7×10^{-5}	7.7×10^{-2}
Ra-226 & Pb-210 + 2 dtrs	2.7×10^{-4}	5.6×10^{-1}
Ra-228 + 1 dtr	3.4×10^{-4}	7.0×10^{-1}
Rn-222 + 4 dtrs	2.8×10^1	5.8×10^4
Sr-90 + 1 dtr	4.9×10^{-4}	1.0×10^0
Tc-99	2.5×10^{-3}	5.2×10^0
Th-228 + 7 dtrs	1.6×10^{-3}	3.4×10^0
Th-230	2.1×10^{-2}	4.4×10^1
Th-232	1.2×10^{-3}	2.5×10^0
U-234	1.7×10^{-2}	3.5×10^1
U-235 + 1 dtr	1.9×10^{-3}	3.9×10^0
U-238 + 2 dtrs	7.0×10^{-2}	1.5×10^2

^aIntakes calculated using concentrations in Table E.3-14 and exposure factors in Table E.3-16.

TABLE E.III-3
INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
CURRENT CONDITIONS - AIR
TRESPASSING CHILD UNDER CURRENT LAND
USE WITHOUT ACCESS CONTROLS

4787

Chemical	Concentration (mg/m ³)	Inhalation
Aroclor-1254	4.0×10^{-7}	7.5×10^{-10}
Arsenic	1.4×10^{-6}	2.6×10^{-9}
Beryllium	2.3×10^{-7}	4.3×10^{-10}
Cadmium	1.7×10^{-6}	3.2×10^{-9}
Chromium	4.1×10^{-6}	7.7×10^{-9}
Nickel	8.5×10^{-6}	1.6×10^{-8}

^aIntakes calculated using concentrations in Table E.3-14 and exposure factors in Table E.3-16.

TABLE E.III-4
INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
CURRENT CONDITIONS - AIR
TRESPASSING CHILD UNDER CURRENT LAND
USE WITHOUT ACCESS CONTROLS

Chemical	Concentration (mg/m ³)	Inhalation
Antimony	7.8×10^{-6}	8.6×10^{-8}
Arsenic	1.4×10^{-6}	1.5×10^{-8}
Barium	1.6×10^{-5}	1.8×10^{-7}
Beryllium	2.3×10^{-7}	2.5×10^{-9}
Cadmium	1.7×10^{-6}	1.9×10^{-8}
Chromium	4.1×10^{-6}	4.5×10^{-8}
Cobalt	3.0×10^{-6}	3.3×10^{-8}
Copper	4.9×10^{-6}	5.4×10^{-8}
Lead	4.5×10^{-6}	5.0×10^{-8}
Manganese	1.6×10^{-4}	1.8×10^{-6}
Molybdenum	1.2×10^{-6}	1.3×10^{-8}
Nickel	8.5×10^{-6}	9.4×10^{-8}
Silver	2.5×10^{-6}	2.8×10^{-8}
Uranium	1.5×10^{-6}	1.7×10^{-8}
Vanadium	5.6×10^{-6}	6.2×10^{-8}
Zinc	1.3×10^{-6}	1.4×10^{-8}

^aIntakes calculated using concentrations in Table E.3-14 and exposure factors in Table E.3-16.

TABLE E.III-5
INTAKES - RADIONUCLIDES (pCi)^a
CURRENT CONDITIONS - SURFACE SOIL
TRESPASSING CHILD UNDER CURRENT LAND
USE WITHOUT ACCESS CONTROLS

4782

Radionuclide	Concentration (pCi/g)	Ingestion
Cs-137 + 1 dtr	1.0×10^0	1.6×10^1
Np-237 + 1 dtr	5.0×10^{-1}	7.8×10^0
Pu-238	3.8×10^{-1}	5.9×10^0
Pu-239/240	1.3×10^{-1}	2.0×10^0
Ra-226 + 8 dtrs	9.5×10^{-1}	1.5×10^1
Ra-228 + 1 dtr	1.2×10^0	1.9×10^1
Sr-90 + 1 dtr	1.7×10^0	2.7×10^1
Tc-99	8.7×10^0	1.4×10^2
Th-228 + 7 dtrs	5.5×10^0	8.6×10^1
Th-230	7.5×10^1	1.2×10^3
Th-232	4.3×10^0	6.7×10^1
U-234	6.0×10^1	9.4×10^2
U-235 + 1 dtr	6.8×10^0	1.1×10^2
U-238 + 2 dtrs	2.4×10^2	3.7×10^3

^aIntakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-16.

TABLE E.III-6
INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
CURRENT CONDITIONS - SURFACE SOIL
TRESPASSING CHILD UNDER CURRENT LAND USE
WITHOUT ACCESS CONTROLS

Chemical	Concentration (mg/kg)	Dermal Contact	Ingestion
Aroclor-1254	1.4×10^0	9.1×10^{-7}	2.0×10^{-8}
Arsenic	4.9×10^0	1.1×10^{-8}	7.0×10^{-8}
Beryllium	8.0×10^{-1}	1.7×10^{-8}	1.1×10^{-8}
Chromium	1.43×10^1	3.1×10^{-7}	2.0×10^{-7}

^a Intakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-16.

TABLE E.III-7
INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
CURRENT CONDITIONS - SURFACE SOIL
TRESPASSING CHILD UNDER CURRENT LAND USE
WITHOUT ACCESS CONTROLS

4787

Chemical	Concentration (mg/kg)	Dermal Contact	Ingestion of Soil
Antimony	2.72×10^1	3.4×10^{-6}	2.3×10^{-6}
Arsenic	4.90×10^0	6.2×10^{-8}	4.1×10^{-7}
Barium	5.69×10^1	7.2×10^{-6}	4.7×10^{-6}
Beryllium	8.00×10^{-1}	1.0×10^{-7}	6.6×10^{-8}
Cadmium	5.80×10^0	7.3×10^{-7}	4.8×10^{-7}
Chromium	1.43×10^1	1.8×10^{-6}	1.2×10^{-6}
Cobalt	1.04×10^1	1.3×10^{-6}	8.6×10^{-7}
Copper	1.70×10^1	2.1×10^{-7}	1.4×10^{-6}
Lead	1.59×10^1	2.0×10^{-6}	1.3×10^{-6}
Manganese	5.74×10^2	7.2×10^{-5}	4.8×10^{-5}
Molybdenum	4.30×10^0	5.4×10^{-7}	3.6×10^{-7}
Nickel	2.94×10^1	1.8×10^{-7}	2.4×10^{-6}
Silver	8.90×10^0	1.1×10^{-6}	7.4×10^{-7}
Uranium	5.22×10^1	6.6×10^{-6}	4.3×10^{-6}
Vanadium	1.96×10^1	2.5×10^{-7}	1.6×10^{-6}
Zinc	4.67×10^1	5.9×10^{-6}	3.9×10^{-6}

^aIntakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-16.

0934

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TABLE E.III-8
INTAKES - RADIONUCLIDES (pCi)^a
CURRENT CONDITIONS - AIR
VISITOR UNDER CURRENT LAND USE WITH ACCESS CONTROLS

Radionuclide	Concentration (pCi/m ³)	Inhalation
Cs-137 + 1 dtr	2.9×10^{-4}	7.3×10^0
Np-237 + 1 dtr	1.4×10^{-4}	3.5×10^0
Pu-238	1.1×10^{-4}	2.8×10^0
Pu-239/240	3.7×10^{-5}	9.3×10^{-1}
Ra-226 & Pb-210 + 2 dtrs	2.7×10^{-4}	6.8×10^0
Ra-228 + 1 dtr	3.4×10^{-4}	8.5×10^0
Rn-222 + 4 dtrs	2.8×10^1	7.0×10^5
Sr-90 + 1 dtr	4.9×10^{-4}	1.2×10^1
Tc-99	2.5×10^{-3}	6.3×10^1
Th-228 + 7 dtrs	1.6×10^{-3}	4.0×10^1
Th-230	2.1×10^{-2}	5.3×10^2
Th-232	1.2×10^{-3}	3.0×10^1
U-234	1.7×10^{-2}	4.3×10^2
U-235 + 1 dtr	1.9×10^{-3}	4.8×10^1
U-238 + 2 dtrs	7.0×10^{-2}	1.8×10^3

^aIntakes calculated using concentrations in Table E.3-14 and exposure factors in Table E.3-16.

0935

TABLE E.III-9
INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
CURRENT CONDITIONS - AIR
VISITOR UNDER CURRENT LAND USE WITH ACCESS CONTROLS

7871

Chemical	Concentration (mg/m ³)	Inhalation
Aroclor-1254	4.0×10^{-7}	5.6×10^{-9}
Arsenic	1.4×10^{-6}	2.0×10^{-8}
Beryllium	2.3×10^{-7}	3.2×10^{-9}
Cadmium	1.7×10^{-6}	2.4×10^{-8}
Chromium	4.1×10^{-6}	5.7×10^{-8}
Nickel	8.5×10^{-6}	1.2×10^{-7}

^aIntakes calculated using concentrations in Table E.3-14 and exposure factors in Table E.3-16.

4787 TABLE E.III-10

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
CURRENT CONDITIONS - AIR
VISITOR UNDER CURRENT LAND USE WITH ACCESS CONTROLS

Chemical	Concentration (mg/m ³)	Inhalation
Antimony	7.8×10^{-6}	3.0×10^{-7}
Arsenic	1.4×10^{-6}	5.5×10^{-8}
Barium	1.6×10^{-5}	6.3×10^{-7}
Beryllium	2.3×10^{-7}	9.0×10^{-9}
Cadmium	1.7×10^{-6}	6.6×10^{-8}
Chromium	4.1×10^{-6}	1.6×10^{-7}
Cobalt	3.0×10^{-6}	1.2×10^{-7}
Copper	4.9×10^{-6}	1.9×10^{-7}
Lead	4.5×10^{-6}	1.8×10^{-7}
Manganese	1.6×10^{-4}	6.3×10^{-6}
Molybdenum	1.2×10^{-6}	4.7×10^{-8}
Nickel	8.5×10^{-6}	3.3×10^{-7}
Silver	2.5×10^{-6}	9.8×10^{-8}
Uranium	1.5×10^{-6}	5.9×10^{-8}
Vanadium	5.6×10^{-6}	2.2×10^{-7}
Zinc	1.3×10^{-6}	5.1×10^{-8}

^aIntakes calculated using concentrations in Table E.3-14 and exposure factors in Table E.3-16.

0937

0937

TABLE E.III-11
INTAKES - RADIONUCLIDES (pCi-yr/g)
CURRENT CONDITIONS - SURFACE SOIL
VISITOR UNDER CURRENT LAND USE WITH ACCESS CONTROLS

4787

Radionuclide	Concentration (pCi/g)	External Exposure
Cs-137 + 1 dtr	1.0×10^0	a
Np-237 + 1 dtr	5.0×10^{-1}	a
Pu-238	3.8×10^{-1}	a
Pu-239/240	1.3×10^{-1}	a
Ra-226 + 8 dtrs	9.5×10^{-1}	a
Ra-228 + 1 dtr	1.2×10^0	a
Sr-90 + 1 dtr	1.7×10^0	a
Tc-99	8.7×10^0	a
Th-228 + 7 dtrs	5.5×10^0	a
Th-230	7.5×10^1	a
Th-232	4.3×10^0	a
U-234	6.0×10^1	a
U-235 + 1 dtr	6.8×10^0	a
U-238 + 2 dtrs	2.4×10^2	a

*No intakes calculated. Risks are calculated directly from soil concentrations for this pathway.

0938

4787

TABLE E.III-12
INTAKES - RADIONUCLIDES (pCi)^a
CURRENT CONDITIONS - AIR
OFF-PROPERTY RME ADULT UNDER ALL LAND USES

Radionuclide	Concentration (pCi/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Cs-137 + 1 dtr	2.5×10^{-5}	2.9×10^0	4.7×10^1	8.3×10^1	1.2×10^2
Np-237 + 1 dtr	1.2×10^{-5}	1.4×10^0	1.9×10^1	1.1×10^{-1}	3.9×10^{-2}
Pu-238	9.5×10^{-6}	1.1×10^0	1.4×10^1	5.0×10^{-4}	4.0×10^{-4}
Pu-239/240	3.2×10^{-6}	3.7×10^{-1}	4.7×10^0	3.7×10^{-4}	2.9×10^{-4}
Ra-226 & Pb-210 +2 dtrs	2.4×10^{-5}	2.8×10^0	3.9×10^1	1.6×10^0	1.2×10^1
Ra-228 + 1 dtr	3.0×10^{-5}	3.5×10^0	4.4×10^1	6.1×10^{-1}	4.4×10^0
Rn-222 + 4 dtrs	2.3×10^0	2.7×10^5	0.0×10^0	0.0×10^0	0.0×10^0
Sr-90 + 1 dtr	4.2×10^{-5}	4.9×10^0	7.9×10^1	4.8×10^0	9.5×10^1
Tc-99	2.2×10^{-4}	2.6×10^1	3.4×10^2	2.0×10^2	9.6×10^2
Th-228 + 7 dtrs	1.4×10^{-4}	1.6×10^1	2.0×10^2	6.1×10^{-2}	2.1×10^{-1}
Th-230	1.9×10^{-3}	2.2×10^2	2.8×10^3	3.4×10^0	1.1×10^1
Th-232	1.1×10^{-4}	1.3×10^1	1.6×10^2	2.0×10^{-1}	6.5×10^{-1}
U-234	1.5×10^{-3}	1.7×10^2	2.2×10^3	2.5×10^1	2.9×10^2
U-235 + 1 dtr	1.7×10^{-4}	2.0×10^1	2.5×10^2	2.8×10^0	3.3×10^1
U-238 + 2 dtrs	6.2×10^{-3}	7.2×10^2	9.1×10^3	1.0×10^2	1.2×10^3

^aIntakes calculated using concentrations in Table E.3-14 and exposure factors in Table E.3-16.

TABLE E.III-13
INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
CURRENT CONDITIONS - AIR
OFF-PROPERTY RME ADULT UNDER ALL LAND USES

4787

Chemical	Concentration (mg/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Aroclor-1254	3.5×10^{-8}	2.3×10^{-9}	3.1×10^{-8}	9.3×10^{-8}	7.9×10^{-8}
Arsenic	1.2×10^{-7}	7.8×10^{-9}	1.2×10^{-7}	3.3×10^{-8}	4.0×10^{-9}
Beryllium	2.0×10^{-8}	1.3×10^{-9}	1.9×10^{-8}	3.7×10^{-9}	1.3×10^{-11}
Cadmium	1.5×10^{-7}	9.7×10^{-9}	1.3×10^{-6}	1.7×10^{-7}	1.2×10^{-6}
Chromium	3.6×10^{-7}	2.3×10^{-8}	4.7×10^{-7}	3.5×10^{-7}	3.9×10^{-7}
Nickel	7.4×10^{-7}	4.8×10^{-8}	3.4×10^{-6}	1.6×10^{-6}	1.1×10^{-6}

^aIntakes calculated using concentrations in Table E.3-14 and exposure factors in Table E.3-16.

0940

4787

TABLE E.III-14

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
CURRENT CONDITIONS - AIR
OFF-PROPERTY RME ADULT UNDER ALL LAND USES

Chemical	Concentration (mg/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Antimony	6.8×10^{-7}	4.4×10^{-8}	9.8×10^{-7}	2.4×10^{-7}	9.7×10^{-8}
Arsenic	1.2×10^{-7}	7.8×10^{-9}	1.2×10^{-7}	3.3×10^{-8}	4.0×10^{-9}
Barium	1.4×10^{-6}	9.1×10^{-8}	3.1×10^{-6}	2.3×10^{-7}	2.2×10^{-6}
Beryllium	2.0×10^{-8}	1.3×10^{-9}	1.9×10^{-8}	3.7×10^{-9}	1.3×10^{-11}
Cadmium	1.5×10^{-7}	9.7×10^{-9}	1.3×10^{-6}	1.7×10^{-7}	1.2×10^{-6}
Chromium	3.6×10^{-7}	2.3×10^{-8}	4.78×10^{-7}	3.5×10^{-7}	3.9×10^{-7}
Cobalt	2.6×10^{-7}	1.7×10^{-8}	3.1×10^{-7}	8.4×10^{-7}	3.4×10^{-7}
Copper	4.2×10^{-7}	2.7×10^{-8}	1.7×10^{-6}	1.8×10^{-6}	1.1×10^{-6}
Lead	4.0×10^{-7}	2.6×10^{-8}	8.2×10^{-7}	7.0×10^{-8}	2.3×10^{-7}
Manganese	1.4×10^{-5}	9.1×10^{-7}	2.5×10^{-5}	2.2×10^{-6}	7.7×10^{-6}
Molybdenum	1.1×10^{-7}	7.1×10^{-9}	1.5×10^{-7}	1.4×10^{-7}	1.4×10^{-7}
Nickel	7.4×10^{-7}	4.8×10^{-8}	3.4×10^{-6}	1.6×10^{-6}	1.1×10^{-6}
Silver	2.2×10^{-7}	1.4×10^{-8}	5.9×10^{-7}	3.9×10^{-7}	1.0×10^{-5}
Uranium	1.3×10^{-6}	8.4×10^{-8}	1.1×10^{-6}	1.2×10^{-8}	1.4×10^{-7}
Vanadium	4.9×10^{-7}	3.2×10^{-8}	5.2×10^{-7}	1.7×10^{-7}	5.5×10^{-9}
Zinc	1.2×10^{-7}	7.8×10^{-9}	1.4×10^{-5}	1.7×10^{-4}	6.7×10^{-5}

^aIntakes calculated using concentrations in Table E.3-14 and exposure factors in Table E.3-16.

4787

TABLE E.III-15
INTAKES - RADIONUCLIDES (pCi)^a
CURRENT CONDITIONS - SURFACE SOIL
OFF-PROPERTY USER OF MEAT AND DAIRY PRODUCTS
UNDER CURRENT LAND USE

Radionuclide	Concentration (pCi/g)	Ingestion of Meat	Ingestion of Milk
Cs-137 + 1 dtr	1.0×10^0	1.6×10^5	2.3×10^5
Np-237 + 1 dtr	5.0×10^{-1}	2.8×10^2	1.0×10^2
Pu-238	3.8×10^{-1}	1.8×10^{-1}	1.5×10^{-1}
Pu-239/240	1.3×10^{-1}	6.2×10^{-2}	5.0×10^{-2}
Ra-226 + 8 dtrs	9.5×10^{-1}	5.5×10^2	3.9×10^3
Ra-228 + 1 dtr	1.2×10^0	6.7×10^2	4.9×10^3
Sr-90 + 1 dtr	1.7×10^0	1.2×10^5	2.3×10^6
Tc-99	8.7×10^0	6.5×10^7	3.0×10^8
Th-228 + 7 dtrs	5.5×10^0	3.2×10^1	1.1×10^2
Th-230	7.5×10^1	4.5×10^2	1.5×10^3
Th-232	4.3×10^0	2.6×10^1	8.6×10^1
U-234	6.0×10^1	2.0×10^4	2.4×10^5
U-235 + 1 dtr	6.8×10^0	2.3×10^3	2.8×10^4
U-238 + 2 dtrs	2.4×10^2	8.2×10^4	9.8×10^5

^aIntakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-16.

0942

4787

TABLE E.III-16

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
CURRENT CONDITIONS - SURFACE SOIL
OFF-PROPERTY USER OF MEAT AND DAIRY PRODUCTS
UNDER CURRENT LAND USE

Chemical	Concentration (mg/kg)	Ingestion of Milk	Ingestion of Meat
Aroclor-1254	1.4×10^0	8.7×10^{-5}	1.0×10^{-4}
Arsenic	4.9×10^0	3.0×10^{-6}	2.5×10^{-5}
Beryllium	8.0×10^{-1}	3.0×10^{-9}	8.2×10^{-7}

^aIntakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-16.

0943

1080

October 12, 1993

TABLE E.IV-17

4787

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
CURRENT CONDITIONS - SURFACE SOIL
OFF-PROPERTY USER OF MEAT AND DAIRY PRODUCTS
UNDER CURRENT LAND USE

Chemical	Concentration (mg/kg)	Ingestion of Milk	Ingestion of Meat
Antimony	2.72×10^1	1.2×10^{-4}	2.9×10^{-4}
Arsenic	4.90×10^0	3.0×10^{-6}	2.5×10^{-5}
Barium	5.69×10^1	6.5×10^{-4}	7.0×10^{-5}
Beryllium	8.00×10^{-1}	3.0×10^{-9}	8.2×10^{-7}
Cadmium	5.80×10^0	6.7×10^{-4}	9.2×10^{-5}
Chromium	1.43×10^1	7.7×10^{-5}	7.1×10^{-5}
Cobalt	1.04×10^1	1.3×10^{-4}	3.2×10^{-4}
Copper	1.70×10^1	2.1×10^{-3}	3.6×10^{-3}
Lead	1.59×10^1	4.5×10^{-5}	1.3×10^{-5}
Manganese	5.74×10^2	1.1×10^{-2}	3.1×10^{-3}
Molybdenum	4.30×10^0	3.4×10^{-4}	3.4×10^{-4}
Nickel	2.94×10^1	4.2×10^{-4}	6.4×10^{-4}
Silver	8.90×10^0	1.5×10^{-2}	5.6×10^{-4}
Uranium	5.20×10^1	1.2×10^{-4}	9.9×10^{-6}
Vanadium	1.96×10^1	1.2×10^{-6}	3.9×10^{-5}
Zinc	4.67×10^1	1.4×10^{-1}	3.6×10^{-1}

^aIntakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-16.

TABLE E.III-18
INTAKES - RADIONUCLIDES (pCi)^a
CURRENT CONDITIONS - SURFACE WATER
OFF-PROPERTY USER OF MEAT AND
DAIRY PRODUCTS UNDER CURRENT LAND USE

Radionuclide	Concentration (pCi/L)	Ingestion of Meat	Ingestion of Milk
Cs-137 + 1 dtr	6.5×10^1	1.2×10^5	2.0×10^5
Ra-226 + 8 dtrs	1.4×10^{-1}	3.1×10^0	2.8×10^1
Ra-228 + 1 dtr	3.7×10^0	8.5×10^1	7.3×10^2
Sr-90 + 1 dtr	3.0×10^1	8.3×10^2	2.0×10^4
Tc-99	1.2×10^3	9.4×10^5	5.3×10^6
Th-230	1.7×10^{-1}	9.4×10^{-2}	3.7×10^{-1}
U-234	5.7×10^2	1.0×10^4	1.5×10^5
U-235 + 1 dtr	3.1×10^1	5.7×10^2	8.2×10^3
U-238 + 2 dtrs	1.2×10^3	2.2×10^4	3.2×10^5

^aIntakes calculated using concentrations in Table E.3-9 and exposure factors in Table.3-16.

4787

TABLE E.III-19
INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
CURRENT CONDITIONS - SURFACE WATER
OFF-PROPERTY USER OF MEAT AND DAIRY PRODUCTS
UNDER CURRENT LAND USE

Chemical	Concentration (mg/L)	Ingestion of Meat	Ingestion of Milk
Arsenic	2.07×10^{-3}	3.2×10^{-7}	3.9×10^{-7}
Benzene	7.95×10^{-3}	2.0×10^{-7}	2.5×10^{-8}

^aIntakes calculated using concentrations in Table E.3-9 and exposure factors in Table E.3-16.

0946

4787

TABLE E.III-20

INTAKES - TOXIC CHEMICALS (mg/kg/day)*
CURRENT CONDITIONS - SURFACE WATER
OFF-PROPERTY USER OF MEAT AND DAIRY PRODUCTS
UNDER CURRENT LAND USE

Chemical	Concentration (mg/L)	Ingestion of Meat	Ingestion of Milk
Antimony	3.50×10^{-3}	7.6×10^{-6}	3.0×10^{-6}
Arsenic	2.07×10^{-3}	3.2×10^{-6}	3.9×10^{-7}
Barium	7.81×10^{-2}	7.7×10^{-5}	7.2×10^{-4}
Copper	1.77×10^{-2}	4.7×10^{-4}	2.8×10^{-4}
Cyanide	7.58×10^{-2}	3.4×10^{-10}	4.8×10^{-10}
Lead	2.52×10^{-3}	2.3×10^{-6}	7.8×10^{-6}
Nickel	1.52×10^{-2}	1.8×10^{-4}	1.2×10^{-4}
Selenium	1.91×10^{-3}	3.1×10^{-5}	3.3×10^{-5}
Silver	1.85×10^{-3}	2.0×10^{-5}	5.4×10^{-4}
Vanadium	1.02×10^{-1}	1.3×10^{-4}	4.2×10^{-6}
Zinc	1.05×10^{-1}	9.1×10^{-1}	3.6×10^{-1}

*Intakes calculated using concentrations in Table E.3-9 and exposure factors in Table E.3-16.

TABLE E.III-21
INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - AIR
TRESPASSING CHILD UNDER CURRENT LAND
USE WITHOUT ACCESS CONTROLS

4787

Radionuclide	Concentration (pCi/m ³)	Inhalation
Cs-137 + dtr	1.6×10^{-3}	3.3×10^0
Np-279 + dtr	1.3×10^{-3}	2.7×10^0
Pu-238	2.9×10^{-4}	6.0×10^{-1}
Pu-239/240	3.0×10^{-3}	6.2×10^0
Ra-226 & Pb-210 + 2 dtrs	6.3×10^{-2}	1.3×10^2
Rn-222 + 4 dtrs	4.8×10^2	9.9×10^5
Sr-90 + 1 dtr	1.5×10^{-3}	3.1×10^0
Tc-99	1.4×10^{-1}	2.9×10^2
Th-230	1.8×10^0	3.7×10^3
Th-232 + 10 dtrs	8.0×10^{-2}	1.7×10^2
U-234	2.6×10^{-1}	5.4×10^2
U-235 + 1 dtr	2.3×10^{-1}	4.8×10^2
U-238 + 2 dtrs	3.6×10^{-1}	7.5×10^2

^aIntakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

4787

TABLE E.III-22
INTAKES - CARCINOGENIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - AIR
TRESPASSING CHILD UNDER CURRENT LAND
USE WITHOUT ACCESS CONTROLS

Radionuclide	Concentration (mg/m ³)	Inhalation
Arsenic	4.2×10^{-3}	7.8×10^{-6}
Beryllium	3.2×10^{-6}	6.0×10^{-9}
Cadmium	5.7×10^{-6}	1.1×10^{-8}
Chromium	4.0×10^{-5}	7.5×10^{-8}
Nickel	5.7×10^{-5}	1.1×10^{-7}
Benzo(a)pyrene	7.5×10^{-7}	1.4×10^{-9}
Benzo(a)anthracene	7.1×10^{-8}	1.3×10^{-10}
Benzo(b)fluoranthene	1.1×10^{-8}	2.1×10^{-11}
Chrysene	7.3×10^{-8}	1.4×10^{-10}
Indeno(1,2,3-cd)pyrene	2.6×10^{-8}	4.9×10^{-11}
Pentachlorophenol	2.6×10^{-7}	4.9×10^{-10}
Tetrachloroethene	1.2×10^{-7}	2.2×10^{-10}
2,3,7,8-TCDF	3.9×10^{-11}	7.3×10^{-14}
HpCDD	6.3×10^{-10}	1.2×10^{-12}
HpCDF	1.7×10^{-10}	3.2×10^{-13}
HxCDD	5.1×10^{-11}	9.5×10^{-14}
HxCDF	5.3×10^{-11}	9.9×10^{-14}
OCDD	2.5×10^{-9}	4.7×10^{-12}
OCDF	1.5×10^{-10}	2.8×10^{-13}

^aIntakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

October 12, 1993

TABLE E.III-23
INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - AIR
TRESPASSING CHILD UNDER CURRENT LAND USE

4787

Chemical	Concentration (mg/m ³)	Inhalation
Antimony	1.3×10^{-5}	1.4×10^{-7}
Arsenic	4.2×10^{-3}	4.6×10^{-5}
Barium	2.2×10^{-3}	2.4×10^{-5}
Beryllium	3.2×10^{-6}	3.5×10^{-8}
Boron	3.1×10^{-5}	3.4×10^{-7}
Cadmium	5.7×10^{-6}	6.3×10^{-8}
Chromium	4.0×10^{-5}	4.4×10^{-7}
Cobalt	8.4×10^{-6}	9.2×10^{-8}
Copper	5.7×10^{-4}	6.3×10^{-6}
Cyanide	3.2×10^{-7}	3.5×10^{-9}
Lead	1.4×10^{-4}	1.5×10^{-6}
Manganese	3.4×10^{-3}	3.7×10^{-5}
Mercury	6.6×10^{-7}	7.3×10^{-9}
Molybdenum	6.0×10^{-5}	6.6×10^{-7}
Nickel	5.7×10^{-5}	6.3×10^{-7}
Selenium	1.0×10^{-5}	1.1×10^{-7}
Silver	8.7×10^{-6}	9.6×10^{-8}
Thallium	3.3×10^{-6}	3.6×10^{-8}
Tin	3.9×10^{-5}	4.3×10^{-7}
Uranium	1.0×10^0	1.1×10^{-2}
Vanadium	1.1×10^{-3}	1.2×10^{-5}
Zinc	6.8×10^{-5}	7.5×10^{-7}

^aIntakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

TABLE E.III-24

INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - SURFACE SOIL/EXPOSED PIT MATERIALS
TRESPASSING CHILD UNDER CURRENT LAND
USE WITHOUT ACCESS CONTROLS

Radionuclide	Concentration (pCi/g)	Ingestion of Soil
Cs-137 + 1 dtr	4.7×10^0	7.3×10^1
Np-237 + 1 dtr	2.9×10^0	4.5×10^1
Pu-238	6.3×10^{-1}	9.8×10^0
Pu-239/240	2.6×10^0	4.1×10^1
Ra-226 + 8 dtrs	4.9×10^1	7.6×10^2
Sr-90 + 1 dtr	3.1×10^0	4.8×10^1
Tc-99	1.8×10^2	2.8×10^3
Th-230	1.6×10^3	2.5×10^4
Th-232 + 10 dtrs	6.2×10^1	9.7×10^2
U-234	2.9×10^2	4.5×10^3
U-235 + 1 dtr	3.5×10^1	5.5×10^2
U-238 + 2 dtrs	6.2×10^2	9.7×10^3

^aIntakes calculated using concentrations in Table E.3-4 and exposure factors in Table E.3-17.

TABLE E.III-25

4788

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL/EXPOSED PIT MATERIALS
TRESPASSING CHILD UNDER CURRENT LAND USE WITHOUT ACCESS CONTROLS

Chemical	Concentration (mg/kg)	Dermal Contact	Ingestion of Soil
Aroclor-1248	4.08×10^{-1}	2.6×10^{-7}	5.8×10^{-9}
Aroclor-1254	1.46×10^0	9.4×10^{-7}	2.1×10^{-8}
Arsenic	3.09×10^3	6.7×10^{-6}	4.4×10^{-5}
Beryllium	3.41×10^0	7.4×10^{-8}	4.8×10^{-8}
Benzo(a)anthracene	5.04×10^{-2}	1.1×10^{-7}	7.2×10^{-10}
Benzo(a)pyrene	3.92×10^{-2}	8.5×10^{-8}	5.6×10^{-10}
Benzo(b)fluoranthene	7.84×10^{-2}	3.4×10^{-8}	1.1×10^{-9}
Chrysene	5.18×10^{-2}	1.1×10^{-7}	7.4×10^{-10}
Indeno(1,2,3-cd)pyrene	1.82×10^{-2}	3.9×10^{-9}	2.6×10^{-10}
Pentachlorophenol	1.82×10^{-1}	3.9×10^{-7}	2.6×10^{-9}
Tetrachloroethene	2.72×10^{-1}	2.3×10^{-7}	3.9×10^{-9}
2,3,7,8-TCDF	2.80×10^{-5}	6.0×10^{-11}	4.0×10^{-13}
HpCDD	2.94×10^{-4}	6.4×10^{-11}	4.2×10^{-12}
HpCDF	1.26×10^{-4}	2.7×10^{-10}	1.8×10^{-12}
HxCDD	4.31×10^{-5}	9.3×10^{-11}	6.1×10^{-13}
HxCDF	3.74×10^{-5}	8.1×10^{-11}	5.3×10^{-13}
OCDD	1.78×10^{-3}	3.8×10^{-9}	2.5×10^{-11}
OCDF	1.04×10^{-4}	2.2×10^{-10}	1.5×10^{-12}

^aIntakes calculated using concentrations in Table E.3-4 and exposure factors in Table E.3-17.

0952

October 12, 1993

TABLE E.III-26

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL/EXPOSED PIT MATERIALS
TRESPASSING CHILD UNDER CURRENT LAND USE WITHOUT ACCESS CONTROLS

Chemical	Concentration (mg/kg)	Ingestion	Dermal Contact
Antimony	3.17×10^1	2.6×10^{-6}	4.0×10^{-6}
Arsenic	3.09×10^3	2.6×10^{-4}	3.9×10^{-5}
Barium	2.59×10^3	2.1×10^{-4}	3.3×10^{-4}
Beryllium	3.41×10^0	2.8×10^{-7}	4.3×10^{-7}
Boron	2.17×10^1	1.8×10^{-6}	2.7×10^{-6}
Cadmium	8.90×10^0	7.4×10^{-7}	1.1×10^{-6}
Chromium	4.33×10^1	3.6×10^{-6}	5.5×10^{-6}
Cobalt	1.53×10^1	1.3×10^{-6}	1.9×10^{-6}
Copper	8.13×10^2	6.7×10^{-5}	1.0×10^{-5}
Cyanide	2.25×10^{-1}	1.9×10^{-8}	2.8×10^{-8}
Lead	1.16×10^2	9.6×10^{-6}	1.5×10^{-5}
Manganese	2.95×10^3	2.4×10^{-4}	3.7×10^{-4}
Mercury	5.22×10^{-1}	4.3×10^{-8}	3.3×10^{-7}
Molybdenum	6.84×10^1	5.7×10^{-6}	8.6×10^{-6}
Nickel	6.85×10^1	5.7×10^{-6}	4.3×10^{-7}
Selenium	7.58×10^0	6.3×10^{-7}	9.6×10^{-7}
Silver	1.46×10^1	1.2×10^{-6}	1.8×10^{-6}
Thallium	3.96×10^0	3.3×10^{-7}	5.0×10^{-7}
Tin	2.90×10^1	2.4×10^{-6}	3.7×10^{-6}
Uranium	9.89×10^2	8.2×10^{-5}	1.2×10^{-4}
Vanadium	9.75×10^2	8.1×10^{-5}	1.2×10^{-4}
Zinc	9.13×10^1	7.6×10^{-6}	1.2×10^{-5}
Pentachlorophenol	1.82×10^{-1}	1.5×10^{-8}	2.3×10^{-6}
Tetrachloroethene	2.72×10^{-1}	2.3×10^{-8}	1.4×10^{-6}

^a Intakes calculated using concentrations in Table E.3-4 and exposure factors in Table E.3-17.

4787

TABLE E.III-27
INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - SEDIMENT
TRESPASSING CHILD UNDER CURRENT LAND
USE WITHOUT ACCESS CONTROLS

Radionuclide	Concentration (pCi/g)	Ingestion
Cs-137 + 1 dtr	1.0×10^0	1.6×10^1
Np-237 + 1 dtr	5.0×10^{-1}	7.8×10^0
Pu-238	4.0×10^{-1}	6.2×10^0
Pu-239/240	1.0×10^{-1}	1.6×10^0
Sr-90 + 1 dtr	1.7×10^0	2.7×10^1
Tc-99	4.7×10^0	7.3×10^1
Th-230	7.5×10^1	1.2×10^3
Th-232 + 10 dtrs	4.3×10^0	6.7×10^1
U-234	6.0×10^1	9.4×10^2
U-235 + 1 dtr	6.7×10^0	1.0×10^2
U-238 + 2 dtrs	2.4×10^2	3.7×10^3

^aIntakes calculated using concentrations in Table E.3-12 and exposure factors in Table E.3-17.

TABLE E.III-28

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - SEDIMENT
TRESPASSING CHILD UNDER CURRENT LAND USE WITHOUT ACCESS CONTROLS

Chemical	Concentration (mg/kg)	Dermal Contact	Ingestion
Aroclor-1254	1.4×10^0	9.1×10^{-7}	2.0×10^{-8}
Aroclor-1260	2.0×10^{-1}	1.3×10^{-7}	2.8×10^{-9}
Arsenic	4.9×10^0	1.1×10^{-8}	7.0×10^{-8}
Beryllium	8.0×10^{-1}	1.7×10^{-8}	1.1×10^{-8}

^aIntakes calculated using concentrations in Table E.3-12 and exposure factors in Table E.3-17.

TABLE E.III-29
INTAKES - TOXIC CHEMICALS (mg/kg/day)*
FUTURE CONDITIONS - SEDIMENT
TRESPASSING CHILD

4787

Chemical	Concentration (mg/kg)	Dermal Contact	Ingestion
Antimony	2.7×10^1	3.4×10^{-6}	2.2×10^{-6}
Arsenic	4.9×10^0	6.2×10^{-8}	4.1×10^{-7}
Barium	5.7×10^1	7.2×10^{-6}	4.7×10^{-6}
Beryllium	8.0×10^{-1}	1.0×10^{-7}	6.6×10^{-8}
Cadmium	5.8×10^0	7.3×10^{-7}	4.8×10^{-7}
Chromium	1.4×10^1	1.8×10^{-6}	1.2×10^{-6}
Cobalt	1.0×10^1	1.3×10^{-6}	8.3×10^{-7}
Copper	1.7×10^1	2.1×10^{-7}	1.4×10^{-6}
Lead	1.6×10^1	2.0×10^{-6}	1.3×10^{-6}
Manganese	5.7×10^2	7.2×10^{-5}	4.7×10^{-5}
Molybdenum	4.3×10^0	5.4×10^{-7}	3.6×10^{-7}
Nickel	2.9×10^1	1.8×10^{-7}	2.4×10^{-6}
Silver	8.9×10^0	1.1×10^{-6}	7.4×10^{-7}
Thallium	7.0×10^{-1}	8.8×10^{-8}	5.8×10^{-8}
Uranium	7.3×10^2	9.2×10^{-5}	6.0×10^{-5}
Vanadium	2.0×10^1	2.5×10^{-7}	1.7×10^{-6}
Zinc	4.7×10^1	5.9×10^{-6}	3.9×10^{-6}

*Intakes calculated using concentrations in Table E.3-12 and exposure factors in Table E.3-17.

4787

TABLE E.III-30

INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - AIR
OFF-PROPERTY RME ADULT UNDER ALL LAND USES

Radionuclide	Concentration (pCi/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Cs-137 + 1 dtr	1.9×10^{-4}	2.2×10^1	3.5×10^2	6.3×10^2	8.8×10^2
Np-237 + 1 dtr	1.4×10^{-4}	1.6×10^1	2.2×10^2	1.2×10^0	4.5×10^{-1}
Pu-238	2.7×10^{-5}	3.1×10^0	4.0×10^1	1.4×10^{-3}	1.1×10^{-3}
Pu-239/240	2.5×10^{-4}	2.9×10^1	3.7×10^2	2.9×10^{-2}	2.3×10^{-2}
Ra-226 + Pb-210 + 2 dtrs	5.2×10^{-3}	6.0×10^2	8.4×10^3	3.5×10^2	2.5×10^3
Rn-222 + 4 dtrs	4.0×10^1	4.6×10^6	NA ^b	NA	NA
Sr-90 + 1 dtr	1.4×10^{-4}	1.6×10^1	2.6×10^2	1.6×10^1	3.2×10^2
Tc-99	1.3×10^{-2}	1.5×10^3	2.0×10^4	1.2×10^4	5.6×10^4
Th-230	1.5×10^{-1}	1.7×10^4	2.2×10^5	2.7×10^2	8.9×10^2
Th-232 + 10 dtrs	6.5×10^{-3}	7.5×10^2	9.7×10^3	1.2×10^1	3.9×10^1
U-234	2.3×10^{-2}	2.7×10^3	3.4×10^4	3.8×10^2	4.5×10^3
U-235 + 1 dtr	2.2×10^{-3}	2.6×10^2	3.2×10^3	3.6×10^1	4.3×10^2
U-238 + 2 dtrs	3.4×10^{-2}	3.9×10^3	5.0×10^4	5.6×10^2	6.7×10^3

^aIntakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

^bNA - Not applicable. Radon is a gas.

TABLE E.III-31

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - AIR
OFF-PROPERTY RME ADULT UNDER ALL LAND USES

4787

Chemical	Concentration (mg/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Arsenic	3.4×10^{-4}	2.2×10^{-5}	3.3×10^{-4}	9.4×10^{-5}	1.1×10^{-5}
Beryllium	2.7×10^{-7}	1.7×10^{-8}	2.6×10^{-7}	5.0×10^{-8}	1.8×10^{-10}
Cadmium	4.8×10^{-7}	3.1×10^{-8}	4.0×10^{-6}	5.5×10^{-7}	4.0×10^{-6}
Chromium	3.3×10^{-6}	2.1×10^{-7}	4.3×10^{-6}	3.2×10^{-6}	3.5×10^{-6}
Nickel	4.8×10^{-2}	3.1×10^{-3}	2.2×10^{-1}	1.0×10^{-1}	6.9×10^{-2}
Aroclor-1248	4.4×10^{-8}	2.9×10^{-9}	3.9×10^{-8}	3.2×10^{-8}	4.0×10^{-8}
Aroclor-1254	4.0×10^{-8}	2.6×10^{-9}	3.5×10^{-8}	1.1×10^{-7}	9.1×10^{-8}
Benzo(a)anthracene	5.7×10^{-9}	3.7×10^{-10}	4.9×10^{-9}	2.7×10^{-9}	3.6×10^{-9}
Benzo(a)pyrene	6.1×10^{-9}	4.0×10^{-10}	5.7×10^{-9}	7.8×10^{-9}	9.9×10^{-9}
Benzo(b)fluoranthene	8.9×10^{-9}	5.8×10^{-10}	7.4×10^{-9}	3.8×10^{-8}	4.8×10^{-8}
Benzo(g,h,i)perylene	2.5×10^{-9}	1.6×10^{-10}	2.1×10^{-9}	4.8×10^{-8}	6.1×10^{-8}
Chrysene	5.9×10^{-9}	3.8×10^{-10}	5.2×10^{-9}	3.0×10^{-9}	3.8×10^{-9}
Indeno(1,2,3-cd)pyrene	2.1×10^{-9}	1.4×10^{-10}	1.7×10^{-9}	1.1×10^{-7}	1.4×10^{-7}
Pentachlorophenol	2.1×10^{-8}	1.4×10^{-1}	1.8×10^{-8}	2.6×10^{-9}	3.2×10^{-9}
Tetrachloroethene	1.5×10^{-8}	9.7×10^{-10}	1.5×10^{-8}	6.4×10^{-12}	8.1×10^{-12}
2,3,7,8-TCDF	3.2×10^{-12}	2.1×10^{-13}	2.6×10^{-12}	3.1×10^{-11}	6.0×10^{-11}
HpCDD	3.3×10^{-11}	2.1×10^{-12}	2.7×10^{-11}	3.2×10^{-10}	6.2×10^{-10}
HpCDF	1.1×10^{-11}	7.1×10^{-13}	9.1×10^{-12}	1.1×10^{-10}	2.1×10^{-10}
HxCDD	4.1×10^{-12}	2.7×10^{-13}	3.4×10^{-12}	4.0×10^{-11}	7.7×10^{-11}
HxCDF	4.3×10^{-12}	2.8×10^{-13}	3.5×10^{-12}	4.2×10^{-11}	8.0×10^{-11}
OCDD	2.0×10^{-10}	1.3×10^{-11}	1.7×10^{-10}	1.9×10^{-9}	3.7×10^{-9}
OCDF	1.2×10^{-11}	7.8×10^{-13}	9.9×10^{-12}	1.2×10^{-10}	2.2×10^{-10}

^aIntakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

October 12, 1993

TABLE E.III-32

4787

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - AIR
OFF-PROPERTY RME ADULT UNDER ALL LAND USES

Chemical	Concentration (mg/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Antimony	1.1×10^{-6}	7.1×10^{-8}	1.6×10^{-6}	3.9×10^{-7}	1.6×10^{-7}
Arsenic	3.4×10^{-4}	2.2×10^{-5}	3.3×10^{-4}	9.4×10^{-5}	1.1×10^{-5}
Barium	2.0×10^{-4}	1.3×10^{-5}	4.4×10^{-4}	3.3×10^{-5}	3.1×10^{-4}
Beryllium	2.7×10^{-7}	1.7×10^{-8}	2.6×10^{-7}	5.0×10^{-8}	1.8×10^{-10}
Boron	2.5×10^{-8}	1.6×10^{-9}	2.0×10^{-8}	4.3×10^{-10}	3.2×10^{-9}
Cadmium	4.8×10^{-7}	3.1×10^{-8}	4.0×10^{-6}	5.5×10^{-7}	4.0×10^{-6}
Chromium	3.3×10^{-6}	2.1×10^{-7}	4.3×10^{-6}	3.2×10^{-6}	3.5×10^{-6}
Cobalt	7.3×10^{-7}	4.7×10^{-8}	8.8×10^{-7}	2.4×10^{-6}	9.5×10^{-7}
Copper	5.5×10^{-5}	3.6×10^{-6}	2.2×10^{-4}	2.3×10^{-4}	1.4×10^{-4}
Cyanide	2.6×10^{-8}	1.7×10^{-9}	3.1×10^{-8}	5.3×10^{-14}	6.7×10^{-14}
Lead	1.1×10^{-5}	7.1×10^{-7}	2.3×10^{-5}	1.9×10^{-6}	6.4×10^{-6}
Manganese	2.8×10^{-4}	1.8×10^{-5}	4.9×10^{-4}	4.4×10^{-5}	1.5×10^{-4}
Mercury	5.5×10^{-8}	3.6×10^{-9}	5.7×10^{-8}	1.5×10^{-6}	1.1×10^{-8}
Molybdenum	5.4×10^{-6}	3.5×10^{-7}	7.5×10^{-7}	7.1×10^{-6}	7.1×10^{-6}
Nickel	4.8×10^{-2}	3.1×10^{-3}	2.2×10^{-1}	1.0×10^{-1}	6.9×10^{-2}
Selenium	8.2×10^{-7}	5.3×10^{-8}	2.1×10^{-6}	2.7×10^{-6}	2.9×10^{-6}
Silver	7.6×10^{-7}	4.9×10^{-8}	2.0×10^{-6}	1.4×10^{-6}	3.6×10^{-5}
Thallium	3.0×10^{-7}	1.9×10^{-8}	2.6×10^{-7}	1.8×10^{-6}	3.6×10^{-7}
Tin	3.2×10^{-6}	2.1×10^{-7}	3.1×10^{-6}	3.0×10^{-5}	1.5×10^{-6}
Uranium	8.9×10^{-2}	5.8×10^{-3}	7.3×10^{-2}	7.2×10^{-4}	9.6×10^{-4}
Vanadium	9.4×10^{-5}	6.1×10^{-6}	1.0×10^{-4}	3.3×10^{-5}	1.0×10^{-6}
Zinc	5.7×10^{-6}	3.7×10^{-7}	6.6×10^{-4}	8.0×10^{-3}	3.2×10^{-3}

^aIntakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

0959

TABLE E.III-33
INTAKES - RADIONUCLIDES (pCi)*
FUTURE CONDITIONS - GROUNDWATER
OFF-PROPERTY RME ADULT UNDER ALL LAND USES

Radionuclide	Concentration (pCi/L)	Ingestion of Drinking Water	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Np-237 + 1 dtr	1.2×10^{-11}	5.9×10^{-7}	1.9×10^{-7}	6.6×10^{-10}	2.5×10^{-10}
Sr-90 + 1 dtr	5.9×10^{-6}	2.9×10^{-1}	1.2×10^{-1}	4.2×10^{-3}	8.8×10^{-2}
Tc-99	3.1×10^0	1.5×10^5	4.8×10^4	1.8×10^4	8.8×10^4
U-234	6.2×10^1	3.0×10^6	9.0×10^5	6.8×10^3	8.1×10^4
U-235 + 1 dtr	1.4×10^1	6.9×10^5	2.1×10^5	1.5×10^3	1.8×10^4
U-238 + 2 dtrs	3.0×10^2	1.5×10^7	4.5×10^6	3.3×10^4	4.1×10^5

*Intakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

TABLE E.III-34

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - GROUNDWATER
OFF-PROPERTY RME ADULT UNDER ALL LAND USES

Chemical	Concentration (mg/L)	Ingestion of Water	Dermal Contact	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Boron	6.77×10^{-3}	1.9×10^{-4}	4.6×10^{-7}	5.5×10^{-5}	3.1×10^{-7}	2.8×10^{-6}
Barium	4.77×10^{-7}	1.3×10^{-8}	3.2×10^{-11}	1.2×10^{-8}	4.7×10^{-10}	4.4×10^{-9}
Cyanide	1.24×10^{-8}	3.4×10^{-10}	8.4×10^{-13}	1.6×10^{-10}	5.5×10^{-17}	7.9×10^{-17}
Uranium	8.87×10^{-1}	2.4×10^{-2}	6.0×10^{-5}	7.3×10^{-3}	5.2×10^{-5}	6.5×10^{-4}
Dichlorodifluoromethane	1.10×10^{-14}	3.0×10^{-16}	0.0×10^0	1.1×10^{-16}	8.5×10^{-21}	1.1×10^{-20}

^aIntakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

TABLE E.III-35
INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - RIVER WATER
GREAT MIAMI RIVER USER UNDER CURRENT LAND USE

Radionuclide	Concentration (pCi/L)	Ingestion of Drinking Water	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk	Incidental Ingestion of Water	Ingestion of Fish
Cs-137 + 1 dtr	2.8×10^{-6}	1.4×10^{-1}	5.5×10^{-2}	5.7×10^{-2}	8.1×10^{-2}	1.8×10^{-4}	1.1×10^{-1}
Np-237 + 1 dtr	4.6×10^{-5}	2.3×10^{-0}	7.3×10^{-1}	2.5×10^{-3}	9.4×10^{-4}	2.9×10^{-3}	9.1×10^{-1}
Pu-238	1.2×10^{-6}	5.9×10^{-2}	1.8×10^{-2}	3.2×10^{-7}	2.7×10^{-7}	7.6×10^{-5}	3.2×10^0
Pu-239/240	3.0×10^{-7}	1.5×10^{-2}	4.4×10^{-3}	8.6×10^{-8}	7.1×10^{-8}	1.9×10^{-5}	9.9×10^{-3}
Sr-90 + 1 dtr	8.7×10^{-4}	4.3×10^1	1.7×10^1	6.2×10^{-1}	1.3×10^1	5.5×10^{-2}	2.9×10^1
Tc-99	2.0×10^{-1}	9.8×10^3	3.1×10^3	1.2×10^3	5.9×10^3	1.3×10^1	2.6×10^3
Th-230	6.6×10^{-5}	3.2×10^0	9.8×10^{-1}	2.5×10^{-4}	8.7×10^{-4}	4.2×10^{-3}	2.6×10^0
Th-232 + 10 dtrs	3.8×10^{-6}	1.9×10^{-1}	5.7×10^{-2}	1.5×10^{-5}	5.0×10^{-5}	2.4×10^{-4}	1.5×10^{-1}
U-234	2.5×10^{-2}	1.2×10^3	3.7×10^2	2.7×10^0	3.4×10^1	1.6×10^0	6.6×10^1
U-235 + 1 dtr	2.9×10^{-3}	1.4×10^2	4.3×10^1	3.2×10^{-1}	3.9×10^0	1.8×10^{-1}	7.7×10^0
U-238 + 2 dtrs	1.0×10^{-1}	5.0×10^3	1.5×10^3	1.1×10^1	1.4×10^2	6.6×10^0	2.7×10^2

^aIntakes calculated using concentrations in Table E.3-11 and exposure factors in Table E.3-17.

0962

E-III-76

4782

TABLE E.III-36
INTAKES RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - SURFACE SOIL
OFF-PROPERTY USER OF MEAT AND DAIRY PRODUCTS
UNDER CURRENT LAND USE

Radionuclide	Concentration (pCi/g)	Ingestion of Meat	Ingestion of Milk
Cs-137 +1 dtr	1.0×10^0	1.6×10^5	2.3×10^5
Np-237 + 1 dtr	5.0×10^{-1}	2.8×10^2	1.0×10^2
Pu-238	3.8×10^{-1}	1.8×10^{-1}	1.5×10^{-1}
Pu-239/240	1.3×10^{-1}	6.2×10^{-2}	5.0×10^{-2}
Ra-226 + 8 dtrs	9.5×10^{-1}	5.3×10^2	3.9×10^3
Sr-90 + 1 dtr	1.7×10^0	1.2×10^5	2.4×10^6
Tc-99	8.7×10^0	6.4×10^7	3.1×10^8
Th-230	7.5×10^1	4.5×10^2	1.5×10^3
Th-232 + 10 dtrs	4.3×10^0	2.6×10^1	8.6×10^1
U-234	6.0×10^1	2.0×10^4	2.4×10^5
U-235 +1 dtr	6.8×10^0	2.4×10^3	2.8×10^4
U-238 + 2 dtrs	2.4×10^2	8.1×10^4	9.6×10^5

^aIntakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-17.

102
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TABLE E.III-37
INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL
OFF-PROPERTY USER OF MEAT AND DAIRY PRODUCTS
UNDER CURRENT LAND USE

Chemical	Concentration (mg/kg)	Ingestion of Meat	Ingestion of Milk
Aroclor-1254	1.40×10^0	1.0×10^{-4}	8.7×10^{-5}
Arsenic	4.90×10^0	2.5×10^{-5}	3.0×10^{-6}
Beryllium	8.00×10^{-1}	8.2×10^{-7}	3.0×10^{-9}

^aIntakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-17.

TABLE E.III-38

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL
OFF-PROPERTY USER OF MEAT AND DAIRY PRODUCTS
UNDER CURRENT LAND USE

Chemical	Concentration (mg/kg)	Ingestion of Milk	Ingestion of Meat
Antimony	2.72×10^1	1.2×10^{-4}	2.9×10^{-4}
Arsenic	4.90×10^0	3.0×10^{-6}	2.5×10^{-5}
Barium	5.69×10^1	6.5×10^{-4}	7.0×10^{-5}
Beryllium	8.00×10^{-1}	3.0×10^{-9}	8.2×10^{-7}
Cadmium	5.80×10^0	6.7×10^{-4}	9.2×10^{-5}
Chromium	1.43×10^1	7.7×10^{-5}	7.1×10^{-5}
Cobalt	1.04×10^1	1.3×10^{-4}	3.2×10^{-4}
Copper	1.70×10^1	2.1×10^{-3}	3.6×10^{-3}
Lead	1.59×10^1	4.5×10^{-5}	1.3×10^{-5}
Manganese	5.74×10^2	1.1×10^{-2}	3.1×10^{-3}
Molybdenum	4.30×10^0	3.4×10^{-4}	3.4×10^{-4}
Nickel	2.94×10^1	4.2×10^{-4}	6.4×10^{-4}
Silver	8.90×10^0	1.5×10^{-2}	5.6×10^{-4}
Uranium	5.20×10^1	1.2×10^{-4}	9.9×10^{-6}
Vanadium	1.96×10^1	1.2×10^{-6}	3.9×10^{-5}
Zinc	4.67×10^1	1.4×10^{-1}	3.6×10^{-1}

^aIntakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-17.

4787

TABLE E.III-39

INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - SURFACE WATER
OFF-PROPERTY USER OF MEAT AND
DAIRY PRODUCTS UNDER CURRENT LAND USE

Radionuclide	Concentration (pCi/L)	Ingestion of Meat	Ingestion of Milk
Cs-137 + 1 dtr	5.6×10^1	1.0×10^5	1.7×10^5
Ra-226 + 8 dtrs	2.5×10^{-1}	5.7×10^0	5.0×10^1
Sr-90 + 1 dtr	2.6×10^1	7.2×10^2	1.7×10^4
Tc-99	1.5×10^3	1.2×10^6	6.6×10^6
Th-230	1.9×10^{-1}	1.0×10^{-1}	4.2×10^{-1}
U-234	7.1×10^2	1.3×10^4	1.9×10^5
U-235 + 1 dtr	4.0×10^1	7.3×10^2	1.1×10^4
U-238 + 2 dtrs	1.7×10^3	3.1×10^4	4.5×10^5

^aIntakes calculated using concentrations in Table E.3-10 and exposure factors in Table E.3-17.

0966

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TABLE E.III-40

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE WATER
OFF-PROPERTY USER OF MEAT AND DAIRY PRODUCTS UNDER CURRENT LAND USE

Chemical	Concentration (mg/L)	Ingestion of Meat	Ingestion of Milk
Arsenic	2.3×10^{-3}	3.5×10^{-6}	4.3×10^{-7}
Benzene	6.9×10^{-3}	1.7×10^{-8}	2.2×10^{-8}

^aIntakes calculated using concentrations in Table E.3-10 and exposure factors in Table E.3-17.

4787

TABLE E.III-41
INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE WATER
OFF-PROPERTY USER OF MEAT AND DAIRY PRODUCTS UNDER CURRENT LAND USE

Chemical	Concentration (mg/L)	Ingestion of Meat	Ingestion of Milk
Antimony	3.0×10^{-3}	6.5×10^{-6}	2.6×10^{-6}
Arsenic	2.3×10^{-3}	3.5×10^{-6}	4.3×10^{-7}
Barium	6.8×10^{-2}	6.7×10^{-5}	6.2×10^{-4}
Copper	1.8×10^{-2}	4.7×10^{-4}	2.8×10^{-4}
Cyanide	7.6×10^{-2}	3.4×10^{-10}	4.8×10^{-10}
Lead	2.2×10^{-3}	2.0×10^{-6}	6.8×10^{-6}
Nickel	1.3×10^{-2}	1.6×10^{-4}	1.0×10^{-4}
Selenium	2.0×10^{-3}	3.2×10^{-5}	3.5×10^{-5}
Silver	3.2×10^{-3}	3.5×10^{-5}	9.4×10^{-4}
Vanadium	1.5×10^{-1}	1.9×10^{-4}	6.2×10^{-6}
Zinc	9.6×10^{-2}	8.3×10^{-1}	3.3×10^{-1}

^aIntakes calculated using concentrations in Table E.3-10 and exposure factors in Table E.3-17.

TABLE E.III-42
INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - AIR
ON-PROPERTY RME ADULT UNDER FUTURE LAND USE

Radionuclide	Concentration (pCi/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Cs-137 + 1 dtr	1.6×10^{-3}	1.9×10^2	3.0×10^3	5.3×10^3	7.4×10^3
Np-237 + 1 dtr	1.3×10^{-3}	1.5×10^2	2.0×10^3	1.1×10^1	4.2×10^0
Pu-238	2.9×10^{-4}	3.4×10^1	4.2×10^2	1.5×10^{-2}	1.2×10^{-2}
Pu-239/240	3.0×10^{-3}	3.5×10^2	4.4×10^3	3.4×10^{-1}	2.8×10^{-1}
Ra-226 & Pb-210 + 2dtrs	6.3×10^{-2}	7.3×10^3	1.0×10^5	4.2×10^3	3.0×10^4
Rn-222 + 4 dtrs	4.8×10^2	5.6×10^7	NA ^b	NA	NA
Sr-90 + 1 dtr	1.5×10^{-3}	1.7×10^2	2.8×10^3	1.7×10^2	3.4×10^3
Tc-99	1.4×10^{-1}	1.6×10^4	7.2×10^{-2}	1.3×10^5	6.1×10^{-5}
Th-230	1.8×10^0	2.1×10^5	2.7×10^6	3.2×10^3	1.1×10^4
Th-232 + 10 dtrs	8.0×10^{-2}	9.3×10^3	1.2×10^5	1.4×10^2	4.7×10^2
U-234	2.6×10^{-1}	3.0×10^4	3.8×10^5	4.3×10^3	5.1×10^4
U-235 + 1 dtr	2.3×10^{-1}	2.7×10^4	3.4×10^5	3.8×10^3	4.5×10^4
U-238 + 2 dtrs	3.6×10^{-1}	4.2×10^4	5.3×10^5	5.9×10^3	7.1×10^4

^aIntakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

^bNA - Not applicable. Radon is a gas.

TABLE E.III-43

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)*
FUTURE CONDITIONS - AIR
ON-PROPERTY RME ADULT UNDER FUTURE LAND USE

4787

Chemical	Concentration (mg/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Arsenic	4.2×10^{-3}	2.7×10^{-4}	4.1×10^{-3}	1.2×10^{-3}	1.4×10^{-4}
Beryllium	3.2×10^{-6}	2.1×10^{-7}	3.1×10^{-6}	6.0×10^{-7}	2.2×10^{-9}
Cadmium	5.7×10^{-6}	3.7×10^{-7}	4.8×10^{-5}	6.5×10^{-6}	4.7×10^{-5}
Chromium	4.0×10^{-5}	2.6×10^{-6}	5.2×10^{-5}	3.9×10^{-5}	4.3×10^{-5}
Nickel	5.7×10^{-5}	3.7×10^{-6}	2.6×10^{-4}	1.2×10^{-4}	8.2×10^{-5}
Aroclor-1248	5.5×10^{-7}	3.6×10^{-8}	4.9×10^{-7}	4.0×10^{-7}	5.0×10^{-7}
Aroclor-1254	5.0×10^{-7}	3.2×10^{-8}	4.4×10^{-7}	1.3×10^{-6}	1.1×10^{-6}
Benzo(a)anthracene	7.1×10^{-8}	4.6×10^{-9}	6.1×10^{-8}	3.4×10^{-8}	4.4×10^{-8}
Benzo(a)pyrene	7.5×10^{-7}	4.9×10^{-8}	7.0×10^{-7}	9.6×10^{-7}	1.2×10^{-6}
Benzo(b)fluoranthene	1.1×10^{-8}	7.1×10^{-10}	9.1×10^{-9}	4.7×10^{-8}	5.9×10^{-8}
Benzo(g,h,i)pyrene	3.2×10^{-8}	2.1×10^{-9}	2.6×10^{-8}	6.2×10^{-7}	7.8×10^{-7}
Chrysene	7.3×10^{-8}	4.7×10^{-9}	6.4×10^{-8}	3.7×10^{-8}	4.6×10^{-8}
Indeno(1,2,3-cd)pyrene	2.6×10^{-8}	1.7×10^{-9}	2.1×10^{-8}	1.4×10^{-6}	1.7×10^{-6}
Pentachlorophenol	2.6×10^{-7}	1.7×10^{-8}	2.3×10^{-7}	3.2×10^{-8}	4.0×10^{-8}
Tetrachloroethene	1.2×10^{-7}	7.8×10^{-9}	1.2×10^{-7}	5.1×10^{-11}	6.5×10^{-11}
2,3,7,8-TCDF	3.9×10^{-11}	2.5×10^{-12}	3.2×10^{-11}	3.8×10^{-10}	7.3×10^{-10}
HpCDD	6.3×10^{-10}	4.1×10^{-11}	5.2×10^{-10}	6.1×10^{-9}	1.2×10^{-8}
HpCDF	1.7×10^{-10}	1.1×10^{-11}	1.4×10^{-10}	1.7×10^{-9}	3.2×10^{-9}
HxCDD	5.1×10^{-11}	3.3×10^{-12}	4.2×10^{-11}	5.0×10^{-10}	9.5×10^{-10}
HxCDF	5.3×10^{-11}	3.4×10^{-12}	4.4×10^{-11}	5.1×10^{-10}	9.9×10^{-10}
OCDD	2.5×10^{-9}	1.6×10^{-10}	2.1×10^{-9}	2.4×10^{-8}	4.7×10^{-8}
OCDF	1.5×10^{-10}	9.7×10^{-12}	1.2×10^{-10}	1.5×10^{-9}	2.8×10^{-9}

*Intakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

0970

TABLE E.III-44
INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - AIR
ON-PROPERTY RME ADULT UNDER FUTURE LAND USE

Chemical	Concentration (mg/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Antimony	1.3×10^{-5}	8.4×10^{-7}	1.9×10^{-5}	4.7×10^{-6}	1.9×10^{-6}
Arsenic	4.2×10^{-3}	2.7×10^{-4}	4.1×10^{-3}	1.2×10^{-3}	1.4×10^{-4}
Barium	2.2×10^{-3}	1.4×10^{-4}	4.9×10^{-3}	3.7×10^{-4}	3.4×10^{-3}
Beryllium	3.2×10^{-6}	2.1×10^{-7}	3.1×10^{-6}	6.0×10^{-7}	2.2×10^{-9}
Boron	3.1×10^{-5}	2.0×10^{-6}	2.5×10^{-5}	5.4×10^{-7}	4.0×10^{-6}
Cadmium	5.7×10^{-6}	3.7×10^{-7}	4.8×10^{-5}	6.5×10^{-6}	4.7×10^{-5}
Chromium	4.0×10^{-5}	2.6×10^{-6}	5.2×10^{-5}	3.9×10^{-5}	4.3×10^{-5}
Cobalt	8.4×10^{-6}	5.4×10^{-7}	1.0×10^{-5}	2.7×10^{-5}	1.1×10^{-5}
Copper	5.7×10^{-4}	3.7×10^{-5}	2.3×10^{-3}	2.4×10^{-3}	1.5×10^{-3}
Cyanide	3.2×10^{-7}	2.1×10^{-8}	3.8×10^{-7}	6.5×10^{-13}	8.2×10^{-13}
Lead	1.4×10^{-4}	9.1×10^{-6}	2.9×10^{-4}	2.5×10^{-5}	8.2×10^{-5}
Manganese	3.4×10^{-3}	2.2×10^{-4}	6.0×10^{-3}	5.3×10^{-4}	1.9×10^{-3}
Mercury	6.6×10^{-7}	4.3×10^{-8}	6.8×10^{-7}	1.8×10^{-5}	1.3×10^{-7}
Molybdenum	6.0×10^{-5}	3.9×10^{-6}	8.3×10^{-5}	7.9×10^{-5}	7.9×10^{-5}
Nickel	5.7×10^{-5}	3.7×10^{-6}	2.6×10^{-4}	1.2×10^{-4}	8.2×10^{-5}
Selenium	1.0×10^{-5}	6.5×10^{-7}	2.6×10^{-5}	3.3×10^{-5}	3.5×10^{-5}
Silver	8.7×10^{-6}	5.6×10^{-7}	2.3×10^{-5}	1.6×10^{-5}	4.1×10^{-4}
Thallium	3.3×10^{-6}	2.1×10^{-7}	2.8×10^{-6}	2.0×10^{-5}	4.0×10^{-6}
Tin	3.9×10^{-5}	2.5×10^{-6}	3.8×10^{-5}	3.7×10^{-4}	1.9×10^{-5}
Uranium	1.0×10^0	6.5×10^{-2}	8.2×10^{-1}	9.0×10^{-3}	1.1×10^{-1}

TABLE E.III-44
(Continued)

Chemical	Concentration (mg/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Vanadium	1.1×10^{-3}	7.1×10^{-5}	1.2×10^{-3}	3.8×10^{-4}	1.2×10^{-5}
Zinc	6.8×10^{-5}	4.4×10^{-6}	7.9×10^{-3}	9.5×10^{-2}	3.8×10^{-2}

^aIntakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

0972

E-III-86

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TABLE E.III-45
INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - SURFACE SOIL
ON-PROPERTY RME ADULT - FOOD INGESTION

Radionuclide	Concentration (pCi/g)	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Cs-137 + 1 dtr	1.0×10^0	3.9×10^4	1.6×10^5	2.3×10^5
Np-237 + 1 dtr	5.0×10^{-1}	6.3×10^3	2.8×10^2	1.0×10^2
Pu-238	3.8×10^{-1}	2.2×10^1	1.8×10^{-1}	1.5×10^{-1}
Pu-239/240	1.3×10^{-1}	7.5×10^0	6.2×10^{-2}	5.0×10^{-2}
Ra-226 + 8 dtrs	9.5×10^{-1}	1.8×10^3	5.3×10^2	3.9×10^3
Sr-90 + 1 dtr	1.7×10^0	5.4×10^5	1.2×10^5	2.4×10^6
Tc-99	8.7×10^0	1.7×10^7	6.4×10^7	3.1×10^8
Th-230	7.5×10^1	8.1×10^3	4.4×10^2	1.5×10^3
Th-232 + 10 dtrs	4.3×10^0	4.8×10^2	2.6×10^1	8.8×10^1
U-234	6.0×10^1	3.0×10^5	2.4×10^4	2.4×10^5
U-235 + 1 dtr	6.8×10^0	3.6×10^4	2.4×10^3	2.8×10^4
U-238 + 2 dtrs	2.4×10^2	1.2×10^6	8.1×10^4	9.6×10^5

^aIntakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-17.

TABLE E.III-46
INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL
ON-PROPERTY RME ADULT - FOOD INGESTION

4787

Chemical	Concentration (mg/kg)	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Aroclor-1254	1.40×10^0	1.7×10^{-5}	1.0×10^{-4}	8.7×10^{-5}
Arsenic	4.90×10^0	2.1×10^{-5}	2.5×10^{-5}	3.0×10^{-6}
Beryllium	8.00×10^{-1}	8.6×10^{-7}	8.2×10^{-7}	3.0×10^{-9}

^aIntakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-17.

0974

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TABLE E.III-47

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL
OFF-PROPERTY RME ADULT - FOOD INGESTION

Chemical	Concentration (mg/kg)	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Antimony	2.72×10^1	5.8×10^{-4}	2.9×10^{-4}	1.2×10^{-4}
Arsenic	4.90×10^0	2.1×10^{-5}	2.5×10^{-5}	3.0×10^{-6}
Barium	5.69×10^1	6.1×10^{-4}	7.0×10^{-5}	6.5×10^{-4}
Beryllium	8.00×10^{-1}	8.6×10^{-7}	8.2×10^{-7}	3.0×10^{-9}
Cadmium	5.80×10^0	6.2×10^{-4}	9.2×10^{-5}	6.7×10^{-4}
Chromium	1.43×10^1	4.6×10^{-5}	7.1×10^{-5}	7.7×10^{-5}
Cobalt	1.04×10^1	5.2×10^{-5}	3.2×10^{-4}	1.3×10^{-4}
Copper	1.70×10^1	3.0×10^{-3}	3.6×10^{-3}	2.1×10^{-3}
Lead	1.59×10^1	1.0×10^{-4}	1.3×10^{-5}	4.5×10^{-5}
Manganese	5.74×10^2	2.1×10^{-2}	3.1×10^{-3}	1.1×10^{-2}
Molybdenum	4.30×10^0	1.8×10^{-4}	3.4×10^{-4}	3.4×10^{-4}
Nickel	2.94×10^1	1.3×10^{-3}	6.4×10^{-4}	4.2×10^{-4}
Silver	8.90×10^0	6.4×10^{-4}	5.6×10^{-4}	1.5×10^{-2}
Uranium	5.20×10^1	1.5×10^{-4}	9.9×10^{-6}	1.2×10^{-4}
Vanadium	1.96×10^1	4.2×10^{-5}	3.9×10^{-5}	1.2×10^{-6}
Zinc	4.67×10^1	3.0×10^{-2}	3.6×10^{-1}	1.4×10^{-1}

^aIntakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-17.

0975

TABLE E.III-48
INTAKES - RADIONUCLIDES (pCi)*
FUTURE CONDITIONS - SURFACE WATER
ON-PROPERTY RME ADULT UNDER FUTURE LAND USE

4787

Radionuclide	Concentration (pCi/L)	Ingestion of Meat	Ingestion of Milk
Cs-137 + 1 dtr	5.6×10^1	1.0×10^5	1.7×10^5
Ra-226 + 8 dtrs	2.5×10^{-1}	5.7×10^0	5.0×10^1
Sr-90 + 1 dtr	2.6×10^1	7.2×10^2	1.7×10^4
Tc-99	1.5×10^3	1.2×10^6	6.6×10^6
Th-230	1.9×10^{-1}	1.0×10^{-1}	4.2×10^{-1}
U-234	7.1×10^2	1.3×10^4	1.9×10^5
U-235 + 1 dtr	4.0×10^1	7.3×10^2	1.1×10^4
U-238 + 2 dtrs	1.7×10^3	3.1×10^4	4.5×10^5

*Intakes calculated using concentrations in Table E.3-10 and exposure factors in Table E.3-17.

0976

4787

TABLE E.III-49
INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE WATER
ON-PROPERTY RME ADULT UNDER FUTURE LAND USE

Chemical	Concentration (mg/L)	Ingestion of Meat	Ingestion of Milk
Arsenic	2.3×10^{-3}	3.5×10^{-6}	4.3×10^{-7}
Benzene	6.9×10^{-3}	1.7×10^{-8}	2.2×10^{-8}

^aIntakes calculated using concentrations in Table E.3-10 and exposure factors in Table E.3-17.

TABLE E.III-50

INTAKES - TOXIC CHEMICALS^a
FUTURE CONDITIONS - SURFACE WATER
ON-PROPERTY RME ADULT UNDER FUTURE LAND USE

4787

Chemical	Concentration (mg/L)	Ingestion of Meat	Ingestion of Milk
Antimony	3.0×10^{-3}	6.5×10^{-6}	2.6×10^{-6}
Arsenic	2.3×10^{-3}	3.5×10^{-6}	4.3×10^{-7}
Barium	6.8×10^{-2}	6.7×10^{-5}	6.2×10^{-4}
Copper	1.8×10^{-2}	4.7×10^{-4}	2.8×10^{-4}
Cyanide	7.6×10^{-2}	3.4×10^{-10}	4.8×10^{-10}
Lead	2.2×10^{-3}	2.0×10^{-6}	6.8×10^{-6}
Nickel	1.3×10^{-2}	1.6×10^{-4}	1.0×10^{-4}
Selenium	2.0×10^{-3}	3.2×10^{-5}	3.5×10^{-5}
Silver	3.2×10^{-3}	3.5×10^{-5}	9.4×10^{-4}
Vanadium	1.5×10^{-1}	1.9×10^{-4}	6.2×10^{-6}
Zinc	9.6×10^{-2}	8.3×10^{-1}	3.3×10^{-1}

^aIntakes calculated using concentrations in Table E.3-10 and exposure factors in Table E.3-17.

0978

4787

TABLE E.III-51
INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - SURFACE SOIL/EXPOSED PIT MATERIALS
ON-PROPERTY RME ADULT UNDER FUTURE LAND USE

Radionuclide	Concentration (pCi/g)	Ingestion of Soil
Cs-137 + 1 dtr	4.7×10^0	2.1×10^4
Np-237 + 1 dtr	2.9×10^0	1.3×10^4
Pu-238	6.3×10^{-1}	2.8×10^3
Pu-239/240	2.6×10^0	1.1×10^4
Ra-226 + 8 dtrs	4.9×10^1	2.2×10^5
Sr-90 + 1 dtr	3.1×10^0	1.4×10^4
Tc-99	1.8×10^2	7.9×10^5
Th-230	1.6×10^3	7.1×10^6
Th-232 + 10 dtrs	6.2×10^1	2.7×10^5
U-234	2.9×10^2	1.3×10^6
U-235 + 1 dtr	3.5×10^1	1.5×10^5
U-238 + 2 dtrs	6.2×10^2	2.7×10^6

^aIntakes calculated using concentrations in Table E.3-4 and exposure factors in Table E.3-17.

TABLE E.III-52

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL/EXPOSED PIT MATERIALS
ON-PROPERTY RME ADULT UNDER FUTURE LAND USE

4787

Chemical	Concentration (mg/kg)	Ingestion of Soil	Dermal Contact
Aroclor-1248	4.08×10^{-1}	1.0×10^{-6}	8.4×10^{-6}
Aroclor-1254	2.08×10^0	5.1×10^{-6}	4.3×10^{-5}
Arsenic	3.09×10^3	7.6×10^{-3}	2.1×10^{-4}
Beryllium	3.41×10^0	8.4×10^{-6}	2.3×10^{-6}
Chromium	4.33×10^1	1.1×10^{-4}	3.0×10^{-5}
Benzo(a)anthracene	5.04×10^{-2}	7.4×10^{-8}	2.1×10^{-6}
Benzo(a)pyrene	3.92×10^{-2}	9.6×10^{-8}	2.7×10^{-6}
Benzo(b)fluoranthene	7.84×10^{-2}	2.0×10^{-7}	1.1×10^{-6}
Chrysene	5.18×10^{-2}	1.3×10^{-7}	3.5×10^{-6}
Indeno(123-cd)pyrene	1.82×10^{-2}	4.5×10^{-8}	1.2×10^{-6}
Pentachlorophenol	1.82×10^{-1}	4.5×10^{-7}	1.2×10^{-5}
Tetrachloroethene	2.72×10^{-1}	6.8×10^{-7}	7.5×10^{-6}
2,3,7,8-TCDF	2.80×10^{-5}	6.9×10^{-11}	1.9×10^{-9}
HpCDD	2.94×10^{-4}	7.3×10^{-10}	2.0×10^{-8}
HpCDF	1.26×10^{-4}	3.1×10^{-10}	8.6×10^{-9}
HxCDD	4.31×10^{-5}	1.1×10^{-10}	3.0×10^{-9}
HxCDF	3.74×10^{-5}	9.2×10^{-11}	2.6×10^{-9}
OCDD	1.78×10^{-3}	4.5×10^{-9}	1.2×10^{-7}
OCDF	1.04×10^{-4}	2.5×10^{-10}	7.1×10^{-9}

^aIntakes calculated using concentrations in Table E.3-4 and exposure factors in Table E.3-17.

1787

TABLE E.III-53

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL/EXPOSED PIT CONTENTS
ON-PROPERTY RME ADULT UNDER FUTURE LAND USE

Chemical	Concentration (mg/kg)	Ingestion of Soil	Dermal Contact
Antimony	3.17×10^1	7.8×10^{-5}	2.2×10^{-5}
Arsenic	3.09×10^3	7.6×10^{-3}	2.1×10^{-4}
Barium	2.59×10^3	6.4×10^{-3}	1.8×10^{-3}
Beryllium	3.41×10^0	8.4×10^{-6}	2.3×10^{-6}
Boron	2.17×10^1	5.3×10^{-5}	1.5×10^{-5}
Cadmium	8.90×10^0	2.1×10^{-5}	6.1×10^{-6}
Chromium	4.33×10^1	1.1×10^{-4}	3.0×10^{-6}
Cobalt	1.53×10^1	3.8×10^{-5}	1.1×10^{-5}
Cyanide	2.25×10^1	5.6×10^{-7}	1.5×10^{-7}
Copper	8.13×10^2	2.0×10^{-3}	5.6×10^{-5}
Lead	1.16×10^2	2.8×10^{-4}	7.9×10^{-5}
Manganese	2.95×10^3	7.3×10^{-3}	2.0×10^{-3}
Mercury	5.22×10^1	1.3×10^{-6}	1.8×10^{-6}
Molybdenum	6.84×10^1	1.7×10^{-4}	4.7×10^{-5}
Nickel	6.85×10^1	1.7×10^{-4}	2.3×10^{-6}
Selenium	7.58×10^0	1.8×10^{-5}	5.2×10^{-6}
Silver	1.46×10^1	3.6×10^{-5}	1.0×10^{-5}
Thallium	3.96×10^0	9.7×10^{-6}	2.7×10^{-7}
Tin	2.90×10^1	7.1×10^{-5}	2.0×10^{-6}
Uranium	9.89×10^2	2.5×10^{-3}	6.8×10^{-4}
Vanadium	9.75×10^2	2.5×10^{-3}	6.7×10^{-5}
Zinc	9.13×10^1	2.3×10^{-4}	6.3×10^{-5}
Pentachlorophenol	1.82×10^1	4.5×10^{-7}	1.2×10^{-5}
Tetrachloroethene	2.72×10^1	6.8×10^{-7}	7.5×10^{-6}

^aIntakes calculated using concentrations in Table E.3-4 and exposure factors in Table E.3-17.

0981

4787

TABLE E.III-54
INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - GROUNDWATER
ON-PROPERTY RME ADULT UNDER FUTURE LAND USE

Radionuclide	Concentration (pCi/L)	Ingestion of Drinking Water	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Np-237 + 1 dtr	1.2×10^{-4}	5.9×10^0	1.9×10^0	6.6×10^{-3}	2.5×10^{-3}
Pu-238	1.3×10^{-1}	6.4×10^3	1.9×10^3	3.5×10^{-2}	2.9×10^{-2}
Ra-226 + 8 dtrs	1.8×10^0	8.8×10^4	3.0×10^4	5.7×10^2	4.2×10^3
Sr-90 + 1 dtr	4.7×10^{-3}	2.3×10^2	9.3×10^1	3.3×10^0	6.6×10^1
Tc-99	1.6×10^1	7.8×10^5	2.5×10^5	9.9×10^4	4.8×10^5
Th-230	1.0×10^0	4.9×10^4	1.5×10^4	3.9×10^0	1.3×10^1
U-234	8.8×10^2	4.3×10^7	1.3×10^7	9.6×10^4	1.2×10^6
U-235 + 1 dtr	2.0×10^2	9.8×10^6	3.0×10^6	2.0×10^4	2.6×10^5
U-238 + 2 dtrs	4.2×10^3	2.1×10^8	6.3×10^7	4.6×10^5	5.7×10^6

^aIntakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

TABLE E.III-55

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - GROUNDWATER
ON-PROPERTY RME ADULT UNDER ALL LAND USES

Chemical	Concentration (mg/L)	Ingestion of Water	Inhalation	Dermal Contact	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Arsenic	5.82×10^{-1}	1.6×10^{-2}	0.0×10^0	4.0×10^{-5}	5.9×10^{-3}	8.9×10^{-4}	1.1×10^{-4}

^aIntakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

TABLE E.III-56

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - GROUNDWATER
ON-PROPERTY RME ADULT UNDER FUTURE LAND USE

Chemical	Concentration (mg/L)	Ingestion of Water	Dermal Contact	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Antimony	1.75×10^{-1}	4.8×10^{-3}	1.2×10^{-5}	2.8×10^{-3}	3.8×10^{-4}	1.5×10^{-4}
Arsenic	5.82×10^{-1}	1.6×10^{-2}	4.0×10^{-5}	5.9×10^{-3}	8.9×10^{-4}	1.1×10^{-4}
Barium	6.51×10^{-1}	1.8×10^{-2}	4.5×10^{-5}	1.7×10^{-2}	6.4×10^{-4}	6.0×10^{-3}
Boron	3.08×10^{-2}	8.4×10^{-4}	2.1×10^{-6}	2.5×10^{-4}	1.4×10^{-6}	1.3×10^{-5}
Cyanide	4.22×10^{-6}	1.2×10^{-7}	2.9×10^{-10}	5.4×10^{-8}	1.9×10^{-14}	2.7×10^{-14}
Lead	5.80×10^{-2}	1.6×10^{-3}	4.0×10^{-6}	1.4×10^{-3}	5.3×10^{-5}	1.8×10^{-4}
Manganese	2.07×10^0	5.7×10^{-2}	1.4×10^{-4}	4.1×10^{-2}	2.0×10^{-3}	7.0×10^{-3}
Uranium	1.26×10^1	3.5×10^{-1}	8.6×10^{-4}	1.0×10^{-1}	7.4×10^{-4}	9.2×10^{-3}

^aIntakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

4787

TABLE E.III-57
INTAKES - RADIONUCLIDES (pCi)*
FUTURE CONDITIONS - PERCHED WATER
ON-PROPERTY RME ADULT UNDER FUTURE LAND USE

Radionuclide	Concentration (pCi/L)	Ingestion
Cs-137 + 1 dtr	9.0×10^1	4.4×10^6
Np-237 + 1 dtr	7.5×10^0	3.7×10^5
Pu-238	4.9×10^{-1}	2.4×10^4
Pu-239/240	5.0×10^{-2}	2.5×10^3
Ra-226 + 8 dtrs	7.2×10^1	3.5×10^6
Sr-90 + 1 dtr	4.0×10^1	2.0×10^6
Tc-99	2.7×10^3	1.3×10^8
Th-230	3.0×10^{-1}	1.5×10^4
Th-232 + 10 dtrs	5.1×10^{-2}	2.5×10^3
U-234	1.5×10^5	7.4×10^9
U-235 + 1 dtr	2.8×10^4	1.4×10^9
U-238 + 2 dtrs	4.3×10^5	2.1×10^{10}

*Intakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

0985

TABLE E.III-58
INTAKES - CHEMICAL CHEMOCARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - PERCHED WATER
ON-PROPERTY RME ADULT UNDER FUTURE LAND USE

4787

Chemical	Concentration (mg/L)	Ingestion
Arsenic	6.32×10^{-1}	1.7×10^{-2}
Beryllium	2.04×10^{-2}	5.6×10^{-4}
Tetrachloroethene	1.40×10^{-1}	3.8×10^{-3}
Vinyl chloride	1.00×10^0	2.7×10^{-2}
Pentachlorophenol	2.00×10^{-1}	5.5×10^{-3}
Aroclor-1248	5.00×10^{-2}	1.4×10^{-3}
Aroclor-1254	1.00×10^{-1}	2.7×10^{-3}
Benzo(a)anthracene	4.00×10^{-2}	1.1×10^{-3}
Benzo(a)pyrene	4.00×10^{-2}	1.1×10^{-3}
Benzo(b)fluoranthene	4.00×10^{-2}	1.1×10^{-3}
Benzo(k)fluoranthene	4.00×10^{-2}	1.1×10^{-3}
Chrysene	4.00×10^{-2}	1.1×10^{-3}
Dibenzo(a,h)anthracene	1.00×10^{-2}	2.7×10^{-4}
Indeno(1,2,3-cd)pyrene	4.00×10^{-2}	1.1×10^{-3}
2,3,7,8-TCDF	5.30×10^{-6}	1.5×10^{-7}
HpCDD	9.40×10^{-7}	2.6×10^{-8}
HpCDF	2.00×10^{-6}	5.5×10^{-8}
HxCDD	7.50×10^{-7}	2.1×10^{-8}
HxCDF	1.20×10^{-6}	3.3×10^{-8}
OCDD	1.80×10^{-6}	4.9×10^{-8}
OCDF	1.10×10^{-6}	3.0×10^{-8}
1,2,3,7,8-PeCDF	1.00×10^{-6}	2.7×10^{-8}
2,3,4,7,8-PeCDF	1.10×10^{-6}	3.0×10^{-8}

^aIntakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

4787

TABLE E.III-59
INTAKES - TOXIC CHEMICALS (mg/kg/day)*
FUTURE CONDITIONS - PERCHED WATER
ON-PROPERTY RME ADULT UNDER FUTURE LAND USE

Chemical	Concentration (mg/L)	Ingestion
Antimony	9.56×10^{-1}	2.6×10^{-2}
Arsenic	6.32×10^{-1}	1.7×10^{-2}
Barium	1.96×10^0	5.4×10^{-2}
Beryllium	2.04×10^{-2}	5.6×10^{-4}
Boron	2.93×10^0	8.0×10^{-2}
Cadmium	1.18×10^{-1}	3.2×10^{-3}
Chromium	1.29×10^{-1}	3.5×10^{-3}
Cobalt	3.38×10^{-1}	9.3×10^{-3}
Copper	9.48×10^{-1}	2.6×10^{-2}
Cyanide	3.60×10^0	9.9×10^{-2}
Lead	6.91×10^{-1}	1.9×10^{-2}
Manganese	2.41×10^0	6.6×10^{-2}
Mercury	2.18×10^{-2}	6.0×10^{-4}
Molybdenum	1.15×10^{-2}	3.2×10^0
Nickel	2.13×10^0	5.8×10^{-2}
Selenium	3.80×10^{-3}	1.0×10^{-4}
Silver	6.67×10^{-2}	1.8×10^{-3}
Thallium	7.54×10^{-1}	2.1×10^{-2}
Tin	8.29×10^0	2.3×10^{-1}
Uranium	5.00×10^2	1.4×10^1
Vanadium	1.44×10^0	3.9×10^{-2}
Zinc	1.79×10^0	4.9×10^{-2}
Acenaphthene	4.00×10^{-2}	1.1×10^{-3}
Anthracene	4.00×10^{-2}	1.1×10^{-3}
Fluoranthene	4.00×10^{-2}	1.1×10^{-3}
Fluorene	4.00×10^{-2}	1.1×10^{-3}
Naphthalene	1.60×10^{-2}	4.4×10^{-4}
Phenanthrene	4.00×10^{-2}	1.1×10^{-3}
Pyrene	4.00×10^{-2}	1.1×10^{-3}

TABLE E.III-59
(Continued)

4787

Chemical	Concentration (mg/L)	Ingestion
4-Nitrophenol	1.00×10^{-2}	2.7×10^{-4}
Pentachlorophenol	2.00×10^{-1}	5.5×10^{-3}
Tetrachloroethene	1.40×10^{-1}	3.8×10^{-3}

*Intakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

TABLE E.III-60

INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - AIR
ON-PROPERTY CT ADULT UNDER FUTURE LAND USE

Radionuclide	Concentration (pCi/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Cs-137 + 1 dtr	1.6×10^{-3}	1.4×10^1	1.9×10^2	3.6×10^2	5.0×10^2
Np-237 + 1 dtr	1.3×10^{-3}	1.1×10^1	1.3×10^2	7.7×10^{-1}	2.8×10^{-1}
Pu-238	2.9×10^{-4}	2.5×10^0	2.7×10^1	1.0×10^{-3}	8.3×10^{-4}
Pu-239/240	3.0×10^{-3}	2.6×10^1	2.9×10^2	2.3×10^{-2}	1.9×10^{-2}
Ra-226 & Pb-210 + 2 dtrs	6.3×10^{-2}	5.4×10^2	6.6×10^3	2.8×10^2	2.0×10^3
Rn-222 + 4 dtrs	4.8×10^2	4.1×10^6	NA ^b	NA	NA
Sr-90 + 1 dtr	1.5×10^{-3}	1.3×10^1	1.8×10^2	1.1×10^1	2.3×10^2
Tc-99	1.4×10^{-1}	1.2×10^3	1.4×10^4	8.7×10^3	4.1×10^4
Th-230	1.8×10^0	1.6×10^4	1.7×10^5	2.2×10^2	7.2×10^2
Th-232 + 10 dtrs	8.0×10^{-2}	6.9×10^2	7.7×10^3	9.6×10^0	3.2×10^1
U-234	2.6×10^{-1}	2.2×10^3	2.5×10^4	2.9×10^2	3.4×10^3
U-235 + 1 dtr	2.3×10^{-1}	2.0×10^3	2.2×10^4	2.5×10^2	3.0×10^3
U-238 + 2 dtrs	3.6×10^{-1}	3.1×10^3	3.4×10^4	4.0×10^2	4.8×10^3

^aIntakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

^bNA - Not applicable. Radon is a gas.

TABLE E.III-61

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - AIR
ON-PROPERTY CT ADULT UNDER FUTURE LAND USE

4787

Chemical	Concentration (mg/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Arsenic	4.2×10^{-3}	2.0×10^{-5}	2.6×10^{-4}	7.8×10^{-5}	9.3×10^{-6}
Beryllium	3.2×10^{-6}	1.5×10^{-8}	2.0×10^{-7}	4.0×10^{-8}	1.5×10^{-10}
Cadmium	5.7×10^{-6}	2.7×10^{-8}	3.1×10^{-6}	4.4×10^{-7}	3.2×10^{-6}
Chromium	4.0×10^{-5}	1.9×10^{-7}	3.4×10^{-6}	2.6×10^{-6}	2.9×10^{-6}
Nickel	5.7×10^{-5}	2.7×10^{-7}	1.7×10^{-5}	8.3×10^{-6}	5.5×10^{-6}
Aroclor-1248	5.5×10^{-7}	2.7×10^{-9}	3.1×10^{-8}	2.7×10^{-8}	3.4×10^{-8}
Aroclor-1254	5.0×10^{-7}	2.4×10^{-9}	2.8×10^{-8}	9.0×10^{-8}	7.7×10^{-8}
Benzo(a)anthracene	7.1×10^{-8}	3.4×10^{-10}	4.0×10^{-9}	2.3×10^{-9}	3.0×10^{-9}
Benzo(a)pyrene	7.5×10^{-7}	3.6×10^{-9}	4.5×10^{-8}	6.5×10^{-8}	8.2×10^{-8}
Benzo(b)fluoranthene	1.1×10^{-8}	5.3×10^{-11}	5.9×10^{-10}	3.1×10^{-9}	4.0×10^{-9}
Benzo(g,h,i)perylene	3.2×10^{-8}	1.5×10^{-10}	1.7×10^{-9}	4.2×10^{-8}	5.2×10^{-8}
Chrysene	7.3×10^{-8}	3.5×10^{-10}	4.2×10^{-9}	2.5×10^{-9}	3.1×10^{-9}
Indeno(1,2,3-cd)pyrene	2.6×10^{-8}	1.3×10^{-10}	1.4×10^{-9}	9.1×10^{-8}	1.1×10^{-7}
Pentachlorophenol	2.6×10^{-7}	1.3×10^{-9}	1.5×10^{-8}	2.1×10^{-9}	2.7×10^{-9}
Tetrachloroethene	1.2×10^{-7}	5.8×10^{-10}	7.8×10^{-9}	3.4×10^{-12}	4.4×10^{-12}
2,3,7,8-TCDF	3.9×10^{-11}	1.9×10^{-13}	2.1×10^{-12}	2.6×10^{-11}	4.9×10^{-11}
HpCDD	6.3×10^{-10}	3.0×10^{-12}	3.4×10^{-11}	4.1×10^{-10}	7.9×10^{-10}
HpCDF	1.7×10^{-10}	8.2×10^{-13}	9.1×10^{-12}	1.1×10^{-10}	2.1×10^{-10}
HxCDD	5.1×10^{-11}	2.5×10^{-13}	2.7×10^{-12}	3.3×10^{-11}	6.4×10^{-11}
HxCDF	5.3×10^{-11}	2.6×10^{-13}	2.8×10^{-12}	3.5×10^{-4}	6.7×10^{-11}
OCDD	2.5×10^{-9}	1.2×10^{-11}	1.3×10^{-10}	1.6×10^{-9}	3.2×10^{-9}
OCDF	1.5×10^{-10}	7.2×10^{-13}	8.0×10^{-12}	9.8×10^{-11}	1.9×10^{-10}

^aIntakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

TABLE E.III-62

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - AIR
ON-PROPERTY CT ADULT UNDER FUTURE LAND USE

Chemical	Concentration (mg/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Antimony	1.3×10^{-5}	4.88×10^{-7}	9.4×10^{-6}	2.3×10^{-6}	9.8×10^{-7}
Arsenic	4.2×10^{-3}	1.58×10^{-4}	2.1×10^{-3}	6.0×10^{-4}	7.3×10^{-5}
Barium	2.2×10^{-3}	8.25×10^{-5}	2.4×10^{-3}	1.9×10^{-4}	1.8×10^{-3}
Beryllium	3.2×10^{-6}	1.20×10^{-7}	1.6×10^{-6}	3.1×10^{-7}	1.1×10^{-9}
Boron	3.1×10^{-5}	1.16×10^{-6}	1.3×10^{-5}	2.8×10^{-7}	2.1×10^{-6}
Cadmium	5.7×10^{-6}	2.14×10^{-7}	2.4×10^{-5}	3.4×10^{-6}	2.5×10^{-5}
Chromium	4.0×10^{-5}	1.50×10^{-6}	2.6×10^{-5}	2.1×10^{-5}	2.2×10^{-5}
Cobalt	8.4×10^{-6}	3.15×10^{-7}	5.1×10^{-6}	1.4×10^{-5}	5.7×10^{-4}
Copper	5.7×10^{-4}	2.14×10^{-5}	1.2×10^{-3}	1.8×10^{-7}	7.6×10^{-4}
Cyanide	3.2×10^{-7}	1.20×10^{-8}	1.9×10^{-7}	3.4×10^{-13}	4.3×10^{-13}
Lead	1.4×10^{-4}	5.25×10^{-6}	1.4×10^{-4}	1.3×10^{-5}	4.3×10^{-5}
Manganese	3.4×10^{-3}	1.28×10^{-4}	3.0×10^{-3}	2.8×10^{-4}	9.8×10^{-4}
Mercury	6.6×10^{-7}	2.48×10^{-8}	3.4×10^{-7}	9.6×10^{-6}	6.9×10^{-8}
Molybdenum	6.0×10^{-5}	2.25×10^{-6}	4.2×10^{-5}	4.1×10^{-5}	4.1×10^{-5}
Nickel	5.7×10^{-5}	2.14×10^{-6}	1.3×10^{-4}	6.4×10^{-5}	4.3×10^{-5}
Selenium	1.0×10^{-5}	3.75×10^{-7}	1.3×10^{-5}	1.7×10^{-5}	1.8×10^{-5}
Silver	8.7×10^{-6}	3.26×10^{-7}	1.2×10^{-5}	8.1×10^{-6}	2.2×10^{-4}
Thallium	3.3×10^{-6}	1.24×10^{-7}	1.4×10^{-6}	1.0×10^{-5}	2.1×10^{-6}
Tin	3.9×10^{-5}	1.46×10^{-6}	1.9×10^{-5}	1.9×10^{-4}	9.7×10^{-6}
Uranium	1.0×10^0	3.75×10^{-2}	4.1×10^{-1}	4.7×10^{-3}	5.6×10^2
Vanadium	1.1×10^{-3}	4.13×10^{-5}	5.9×10^{-4}	2.0×10^{-4}	6.4×10^{-6}
Zinc	6.8×10^{-5}	2.55×10^{-6}	4.0×10^{-3}	5.0×10^{-2}	2.0×10^{-2}

^aIntakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

TABLE E.III-63
INTAKES - RADIONUCLIDES (pCi)*
FUTURE CONDITIONS - SURFACE SOIL
ON-PROPERTY CT ADULT - FOOD INGESTION

4787

Radionuclide	Concentration (pCi/g)	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Cs-137 + 1 dtr	1.0×10^0	2.5×10^3	1.1×10^4	1.5×10^4
Np-237 + 1 dtr	5.0×10^{-1}	4.1×10^2	1.9×10^1	6.9×10^0
Pu-238	3.8×10^{-1}	1.4×10^0	1.2×10^{-2}	9.9×10^{-3}
Pu-239/240	1.3×10^{-1}	4.8×10^{-1}	4.2×10^{-3}	3.4×10^{-3}
Ra-226 + 8 dtrs	9.5×10^{-1}	1.2×10^{-2}	3.6×10^1	2.6×10^2
Sr-90 + 1 dtr	1.7×10^0	3.5×10^4	7.8×10^3	1.6×10^5
Tc-99	8.7×10^0	1.1×10^6	4.3×10^6	2.1×10^7
Th-230	7.5×10^1	5.2×10^2	3.0×10^1	9.9×10^1
Th-232 + 10 dtrs	4.3×10^0	3.1×10^1	1.7×10^0	5.9×10^0
U-234	6.0×10^1	1.9×10^4	1.4×10^3	1.6×10^4
U-235 + 1 dtr	6.8×10^0	2.3×10^3	1.6×10^2	1.9×10^3
U-238 + 2 dtrs	2.4×10^2	7.9×10^4	6.4×10^3	6.4×10^4

*Intakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-17.

0992

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TABLE E.III-64

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL
ON-PROPERTY CT ADULT - FOOD INGESTION

Chemical	Concentration (mg/kg)	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Aroclor-1254	1.40×10^0	1.1×10^{-6}	6.9×10^{-6}	5.9×10^{-6}
Arsenic	4.90×10^0	1.4×10^{-6}	1.7×10^{-6}	2.0×10^{-7}
Beryllium	8.00×10^{-1}	5.5×10^{-6}	5.5×10^{-8}	2.0×10^{-10}

^aRisks calculated using concentrations in Table E.3-5 and exposure factors in Table E.3-17.

TABLE E.III-65
INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL
ON-PROPERTY CT ADULT - FOOD INGESTION

4787

Chemical	Concentration (mg/kg)	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Antimony	2.72×10^1	2.9×10^{-4}	1.5×10^{-4}	6.1×10^{-5}
Arsenic	4.90×10^0	1.1×10^{-5}	1.3×10^{-5}	1.6×10^{-6}
Barium	5.69×10^{-1}	3.1×10^{-6}	3.7×10^{-7}	3.4×10^{-6}
Beryllium	8.00×10^{-1}	4.3×10^{-7}	4.3×10^{-7}	1.5×10^{-9}
Cadmium	5.80×10^0	3.1×10^{-4}	4.8×10^{-5}	3.5×10^{-4}
Chromium	1.43×10^1	2.3×10^{-5}	3.7×10^{-5}	4.0×10^{-5}
Cobalt	1.04×10^1	2.6×10^{-5}	1.7×10^{-4}	6.7×10^{-5}
Copper	1.70×10^1	1.5×10^{-3}	1.9×10^{-3}	1.1×10^{-3}
Lead	1.59×10^1	5.1×10^{-5}	7.1×10^{-6}	2.4×10^{-5}
Manganese	5.74×10^2	1.0×10^{-2}	1.6×10^{-3}	5.6×10^{-3}
Molybdenum	4.30×10^0	9.3×10^{-5}	1.8×10^{-4}	1.8×10^{-4}
Nickel	2.94×10^1	6.4×10^{-4}	3.3×10^{-4}	2.2×10^{-4}
Silver	8.90×10^0	3.2×10^{-4}	2.9×10^{-4}	7.9×10^{-3}
Uranium	5.20×10^1	7.5×10^{-5}	5.2×10^{-6}	6.2×10^{-5}
Vanadium	1.96×10^1	2.1×10^{-5}	2.0×10^{-5}	6.5×10^{-7}
Zinc	4.67×10^1	1.5×10^{-2}	1.9×10^{-1}	7.6×10^{-2}

^aIntakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-17.

4787

TABLE E.III-66
INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - SURFACE WATER
ON-PROPERTY CT RESIDENT ADULT UNDER FUTURE LAND USE

Radionuclide	Concentration (pCi/L)	Ingestion of Meat	Ingestion of Milk
Cs-137 + 1 dtr	5.6×10^1	6.9×10^3	1.2×10^4
Ra-226 + 8 dtrs	2.5×10^{-1}	3.8×10^{-1}	3.3×10^0
Sr-90 + 1 dtr	2.6×10^1	4.8×10^1	1.1×10^3
Tc-99	1.5×10^3	7.9×10^4	4.5×10^5
Th-230	1.9×10^{-1}	7.1×10^{-3}	2.8×10^{-2}
U-234	7.1×10^2	8.8×10^2	1.3×10^4
U-235 + 1 dtr	4.0×10^1	5.0×10^1	6.9×10^2
U-238 + 2 dtrs	1.7×10^3	2.1×10^3	3.0×10^4

^aIntakes calculated using concentrations in Table E.3-10 and exposure factors in Table E.3-17.

TABLE E.III-67

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE WATER
ON-PROPERTY CT RESIDENT ADULT UNDER FUTURE LAND USE

4787

Chemical	Concentration (mg/L)	Ingestion of Meat	Ingestion of Milk
Arsenic	2.3×10^{-3}	2.4×10^{-7}	2.9×10^{-8}
Benzene	6.9×10^{-3}	1.1×10^{-9}	1.5×10^{-9}

^aIntakes calculated using concentrations in Table E.3-10 and exposure factors in Table E.3-17.

TABLE E.III-68

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE WATER
ON-PROPERTY CT RESIDENT ADULT UNDER FUTURE LAND USE

Chemical	Concentration (mg/L)	Ingestion of Milk	Ingestion of Meat
Antimony	3.0×10^{-3}	1.4×10^{-6}	3.4×10^{-6}
Arsenic	2.3×10^{-3}	2.2×10^{-7}	1.8×10^{-6}
Barium	6.8×10^{-2}	3.3×10^{-4}	3.5×10^{-5}
Copper	1.8×10^{-2}	1.5×10^{-4}	2.5×10^{-4}
Cyanide	7.6×10^{-2}	2.5×10^{-10}	1.8×10^{-10}
Lead	2.2×10^{-3}	3.5×10^{-6}	1.1×10^{-6}
Nickel	1.3×10^{-2}	5.5×10^{-5}	8.2×10^{-5}
Selenium	2.0×10^{-3}	1.8×10^{-5}	1.7×10^{-5}
Silver	3.2×10^{-3}	4.9×10^{-4}	1.8×10^{-5}
Vanadium	1.5×10^{-1}	3.3×10^{-6}	1.0×10^{-4}
Zinc	9.6×10^{-2}	1.7×10^{-1}	4.4×10^{-1}

^aIntakes calculated using concentrations in Table E.3-10 and exposure factors in Table E.3-17.

TABLE E.III-69
INTAKES - RADIONUCLIDES (pCi)*
FUTURE CONDITIONS - SURFACE SOIL/EXPOSED PIT MATERIAL
ON-PROPERTY CT ADULT UNDER FUTURE LAND USE

4787

Radionuclide	Concentration (pCi/g)	Ingestion of Soil
Cs-137 + 1 dtr	4.7×10^0	2.1×10^3
Np-237 + 1 dtr	2.9×10^0	1.3×10^3
Pu-238	6.3×10^{-1}	2.8×10^2
Pu-239/240	2.6×10^0	1.2×10^3
Ra-226 + 8 dtrs	4.9×10^1	2.2×10^4
Sr-90 + 1 dtr	3.1×10^0	1.4×10^3
Tc-99	1.8×10^2	8.0×10^4
Th-230	1.6×10^3	7.1×10^5
Th-232 + 10 dtrs	6.2×10^1	2.8×10^4
U-234	2.9×10^2	1.3×10^5
U-235 + 1 dtr	3.5×10^1	1.6×10^4
U-238 + 2 dtrs	6.2×10^2	2.8×10^5

*Intakes calculated using concentrations in Table E.3-4 and exposure factors in Table E.3-17.

0998

TABLE E.III-70

4787

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL/EXPOSED PIT CONTENTS
ON-PROPERTY CT ADULT UNDER FUTURE LAND USE

Chemical	Concentration (mg/kg)	Ingestion of Soil	Dermal Contact
Aroclor-1248	4.08×10^{-1}	5.6×10^{-8}	1.2×10^{-5}
Aroclor-1254	1.46×10^0	2.0×10^{-7}	4.4×10^{-7}
Arsenic	3.09×10^3	4.3×10^{-4}	3.1×10^{-6}
Beryllium	3.41×10^0	4.7×10^{-7}	3.4×10^{-8}
Benzo(a)anthracene	5.04×10^{-2}	7.0×10^{-9}	5.1×10^{-8}
Benzo(a)pyrene	3.92×10^{-2}	5.4×10^{-9}	4.0×10^{-8}
Benzo(b)fluoranthene	7.84×10^{-2}	1.1×10^{-8}	1.6×10^{-8}
Chrysene	5.18×10^{-2}	7.1×10^{-9}	5.2×10^{-8}
Indeno(123-cd)pyrene	1.82×10^{-2}	2.5×10^{-9}	1.8×10^{-9}
Pentachlorophenol	1.82×10^{-1}	2.5×10^{-8}	1.8×10^{-7}
Tetrachloroethene	2.72×10^{-1}	3.8×10^{-8}	1.1×10^{-7}
2,3,7,8-TCDF	2.80×10^{-5}	3.9×10^{-12}	2.8×10^{-11}
HpCDD	2.94×10^{-4}	4.1×10^{-11}	3.0×10^{-10}
HpCDF	1.26×10^{-4}	1.7×10^{-11}	1.3×10^{-10}
HxCDD	4.31×10^{-5}	5.9×10^{-12}	4.4×10^{-11}
HxCDF	3.74×10^{-5}	5.2×10^{-12}	3.8×10^{-11}
OCDD	1.78×10^{-3}	2.5×10^{-10}	1.8×10^{-9}
OCDF	1.04×10^{-4}	1.4×10^{-11}	1.1×10^{-10}

^aIntakes calculated using concentrations in Table E.3-4 and exposure factors in Table E.3-17.

0999

TABLE E.III-71

4787

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL/EXPOSED PIT CONTENTS
ON-PROPERTY CT ADULT UNDER FUTURE LAND USE

Chemical	Concentration (mg/kg)	Ingestion of Soil	Dermal Contact
Antimony	3.17×10^1	3.4×10^{-5}	2.5×10^{-6}
Arsenic	3.09×10^3	3.3×10^{-3}	2.4×10^{-5}
Barium	2.59×10^3	2.8×10^{-3}	2.0×10^{-4}
Beryllium	3.41×10^0	3.7×10^{-6}	2.7×10^{-7}
Boron	2.17×10^1	2.3×10^{-5}	1.7×10^{-6}
Cadmium	8.90×10^0	9.6×10^{-6}	7.0×10^{-7}
Chromium	4.33×10^1	4.7×10^{-5}	3.4×10^{-6}
Cobalt	1.53×10^1	1.7×10^{-5}	1.2×10^{-6}
Copper	8.13×10^2	8.8×10^{-4}	6.4×10^{-6}
Cyanide	2.25×10^{-1}	2.4×10^{-7}	1.8×10^{-8}
Lead	1.16×10^2	1.3×10^{-4}	9.1×10^{-6}
Manganese	2.95×10^3	3.2×10^{-3}	2.3×10^{-4}
Mercury	5.22×10^{-1}	5.6×10^{-7}	2.0×10^{-7}
Molybdenum	6.84×10^1	7.4×10^{-5}	5.4×10^{-6}
Nickel	6.85×10^1	7.4×10^{-5}	2.7×10^{-7}
Selenium	7.58×10^0	8.2×10^{-6}	5.9×10^{-7}
Silver	1.46×10^1	1.6×10^{-5}	1.1×10^{-6}
Thallium	3.96×10^0	4.3×10^{-6}	3.1×10^{-7}
Tin	2.90×10^1	3.1×10^{-5}	2.3×10^{-7}
Uranium	9.89×10^2	1.1×10^{-3}	7.7×10^{-5}
Vanadium	9.75×10^2	1.1×10^{-3}	7.6×10^{-6}
Zinc	9.13×10^1	9.9×10^{-5}	7.1×10^{-6}
Pentachlorophenol	1.82×10^{-1}	2.0×10^{-7}	1.4×10^{-6}
Tetrachloroethene	2.72×10^{-1}	2.9×10^{-7}	8.5×10^{-7}

^aIntakes calculated using concentrations in Table E.3-4 and exposure factors in Table E.3-17.

1000

TABLE E.III-72
INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - GROUNDWATER
ON-PROPERTY CT ADULT UNDER FUTURE LAND USE

Radionuclide	Concentration (pCi/L)	Ingestion of Water	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Np-237 + 1 dtr	1.2×10^{-4}	4.2×10^{-1}	1.2×10^{-1}	4.5×10^{-4}	1.7×10^{-4}
Pu-238	1.3×10^{-1}	4.5×10^2	1.2×10^2	2.4×10^{-3}	2.0×10^{-3}
Ra-226 + 8 dtrs	1.8×10^0	6.2×10^3	1.9×10^3	3.8×10^1	2.8×10^2
Sr-90 + 1 dtr	4.7×10^{-3}	1.6×10^1	6.0×10^0	2.2×10^{-1}	4.5×10^0
Tc-99	1.6×10^1	5.5×10^4	1.6×10^4	6.7×10^3	3.2×10^4
Th-230	1.0×10^0	3.5×10^3	9.7×10^2	2.6×10^{-1}	8.9×10^{-1}
U-234	8.8×10^2	3.0×10^6	8.3×10^5	6.4×10^3	7.9×10^4
U-235 + 1 dtr	2.0×10^2	6.9×10^5	1.9×10^5	1.4×10^3	1.8×10^4
U-238 + 2 dtrs	4.2×10^3	1.5×10^7	4.1×10^6	3.1×10^4	3.8×10^5

^aIntakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

TABLE E.III-73

INTAKES - CHEMICAL CHEMOCARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - GROUNDWATER
ON-PROPERTY CT ADULT UNDER ALL FUTURE USES

Chemical	Concentration (mg/L)	Ingestion of Water	Inhalation	Dermal Contact	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Arsenic	5.82×10^{-1}	1.1×10^{-3}	0.0×10^0	2.7×10^{-6}	3.8×10^{-4}	6.0×10^{-5}	7.3×10^{-6}

^aIntakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

TABLE E.III-74

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - GROUNDWATER
ON-PROPERTY CT ADULT UNDER FUTURE LAND USE

1008

Chemical	Concentration (mg/L)	Ingestion of Water	Dermal Contact	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Antimony	1.75×10^{-1}	2.6×10^{-3}	6.4×10^{-6}	1.4×10^{-3}	2.0×10^{-4}	8.0×10^{-5}
Arsenic	5.82×10^{-1}	8.8×10^{-3}	2.1×10^{-5}	3.0×10^{-3}	4.7×10^{-4}	5.7×10^{-5}
Barium	6.51×10^{-1}	9.8×10^{-3}	2.4×10^{-5}	8.3×10^{-3}	3.3×10^{-4}	3.1×10^{-3}
Boron	3.08×10^{-2}	4.7×10^{-4}	1.1×10^{-6}	1.3×10^{-4}	7.4×10^{-7}	6.6×10^{-6}
Cyanide	4.22×10^{-6}	6.4×10^{-8}	1.5×10^{-10}	2.7×10^{-8}	9.8×10^{-15}	1.4×10^{-14}
Lead	5.80×10^{-2}	8.8×10^{-4}	2.1×10^{-6}	6.9×10^{-4}	2.8×10^{-5}	9.3×10^{-5}
Manganese	2.07×10^0	3.1×10^{-2}	7.6×10^{-5}	2.1×10^{-2}	1.0×10^{-3}	3.7×10^{-3}
Uranium	1.26×10^1	1.9×10^{-1}	4.6×10^{-4}	5.2×10^{-2}	3.9×10^{-4}	4.8×10^{-3}

^aIntakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

E-III-117

1008

TABLE E.III-75
INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - PERCHED WATER
ON-PROPERTY CT ADULT UNDER FUTURE LAND USE

4787

Radionuclides	Concentration (pCi/L)	Ingestion
Cs-137 + 1 dtr	9.0×10^1	3.1×10^5
Np-237 + 1 dtr	7.5×10^0	2.6×10^4
Pu-238	4.9×10^{-1}	1.7×10^3
Pu-239/240	5.0×10^{-2}	2.5×10^3
Ra-226 + 8 dtrs	7.2×10^1	2.5×10^5
Sr-90 + 1 dtr	4.0×10^1	1.4×10^5
Tc-99	2.7×10^3	9.4×10^6
Th-230	3.0×10^{-1}	1.0×10^3
Th-232 + 10 dtrs	5.1×10^{-2}	1.8×10^2
U-234	1.5×10^5	5.2×10^8
U-235 + 1 dtr	2.8×10^4	9.7×10^7
U-238 + 2 dtrs	4.3×10^5	1.5×10^9

^aIntakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

1004

TABLE E.III-76

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - PERCHED WATER
ON-PROPERTY CT ADULT UNDER FUTURE LAND USE

Chemical	Concentration (mg/L)	Ingestion
Arsenic	6.32×10^{-1}	1.2×10^{-3}
Beryllium	2.04×10^{-2}	4.0×10^{-5}
Tetrachloroethene	1.40×10^{-1}	2.7×10^{-4}
Vinyl chloride	1.00×10^0	1.9×10^{-3}
Pentachlorophenol	2.00×10^{-1}	3.9×10^{-4}
Aroclor-1248	5.00×10^{-2}	9.7×10^{-5}
Aroclor-1254	1.00×10^{-1}	1.9×10^{-4}
Benzo(a)anthracene	4.00×10^{-2}	7.8×10^{-5}
Benzo(a)pyrene	4.00×10^{-2}	7.8×10^{-5}
Benzo(b)fluoranthene	4.00×10^{-2}	7.8×10^{-5}
Benzo(k)fluoranthene	4.00×10^{-2}	7.8×10^{-5}
Chrysene	4.00×10^{-2}	7.8×10^{-5}
Dibenzo(a,h)anthracene	1.00×10^{-2}	2.0×10^{-5}
Indeno(1,2,3-cd)pyrene	4.00×10^{-2}	7.8×10^{-5}
2,3,7,8-TCDF	5.30×10^{-6}	1.0×10^{-8}
HpCDD	9.40×10^{-7}	1.8×10^{-9}
HpCDF	2.00×10^{-6}	3.9×10^{-9}
HxCDD	7.50×10^{-7}	1.5×10^{-9}
HxCDF	1.20×10^{-6}	2.3×10^{-9}
OCDD	1.80×10^{-6}	3.5×10^{-9}
OCDF	1.10×10^{-6}	2.1×10^{-9}
1,2,3,7,8-PeCDF	1.00×10^{-6}	1.9×10^{-9}
2,3,4,7,8-PeCDF	1.10×10^{-6}	2.1×10^{-9}

^aIntakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

TABLE E.III-77
INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - PERCHED WATER
ON-PROPERTY CT ADULT UNDER FUTURE LAND USE

4787

Chemical	Concentration (mg/L)	Ingestion
Antimony	9.56×10^{-1}	1.4×10^{-2}
Arsenic	6.32×10^{-1}	9.5×10^{-3}
Barium	1.96×10^0	3.0×10^{-2}
Beryllium	2.04×10^{-2}	3.1×10^{-4}
Boron	2.93×10^0	4.4×10^{-2}
Cadmium	1.18×10^{-1}	1.8×10^{-1}
Chromium	1.29×10^{-1}	1.9×10^{-3}
Cobalt	3.38×10^{-1}	5.1×10^{-3}
Copper	9.48×10^{-1}	1.4×10^{-2}
Cyanide	3.60×10^0	5.4×10^{-2}
Lead	6.91×10^{-1}	1.0×10^{-2}
Manganese	2.41×10^0	3.6×10^{-2}
Mercury	2.18×10^{-2}	3.3×10^{-4}
Molybdenum	1.15×10^2	1.7×10^0
Nickel	2.13×10^0	3.2×10^{-2}
Selenium	3.80×10^{-3}	5.7×10^{-5}
Silver	6.67×10^{-2}	1.0×10^{-3}
Thallium	7.54×10^{-1}	1.1×10^{-2}
Tin	8.29×10^0	1.3×10^{-1}
Uranium	5.00×10^2	7.6×10^0
Vanadium	1.44×10^0	2.2×10^{-2}
Zinc	1.79×10^0	2.7×10^{-2}
Acenaphthene	4.00×10^{-2}	6.0×10^{-4}
Anthracene	4.00×10^{-2}	6.0×10^{-4}
Fluoranthene	4.00×10^{-2}	6.0×10^{-4}
Fluorene	4.00×10^{-2}	6.0×10^{-4}
Nephthalene	1.60×10^{-2}	2.4×10^{-4}
Phenanthrene	4.00×10^{-2}	6.0×10^{-4}
Pyrene	4.00×10^{-2}	6.0×10^{-4}

4787

TABLE E.III-77
(Continued)

Chemical	Concentration (mg/L)	Ingestion
4-Nitrophenol	1.00×10^{-2}	1.5×10^{-4}
Pentachlorophenol	2.00×10^{-1}	3.0×10^{-3}
Tetrachloroethene	1.40×10^{-1}	2.1×10^{-3}

*Intakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

TABLE E.III-78

INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - AIR
ON-PROPERTY RME CHILD UNDER FUTURE LAND USE

Radionuclide	Concentration (pCi/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Cs-137 + 1 dtr	1.6×10^{-3}	3.4×10^0	2.1×10^2	1.8×10^2	1.9×10^3
Np-237 + 1 dtr	1.3×10^{-3}	2.7×10^0	6.8×10^{-4}	3.8×10^{-1}	1.1×10^0
Pu-238	2.9×10^{-4}	6.1×10^{-1}	3.1×10^1	5.1×10^{-4}	3.2×10^{-3}
Pu-239/240	3.0×10^{-3}	6.3×10^0	3.1×10^2	1.1×10^{-2}	7.1×10^{-2}
Ra-226 & Pb-210 + 2 dtrs	6.3×10^{-2}	1.3×10^2	7.3×10^3	1.4×10^2	7.8×10^3
Rn-222 + 4 dtrs	4.8×10^2	1.0×10^6	NA ^b	NA	NA
Sr-90 + 1 dtr	1.5×10^{-3}	3.2×10^0	2.0×10^2	5.6×10^0	8.7×10^2
Tc-99	1.4×10^{-1}	2.9×10^2	1.5×10^4	4.3×10^3	1.6×10^5
Th-230	1.8×10^0	3.8×10^3	1.9×10^5	1.1×10^2	2.7×10^3
Th-232 + 10 dtrs	8.0×10^{-2}	1.7×10^2	8.5×10^3	4.7×10^0	1.2×10^2
U-234	2.6×10^{-1}	5.5×10^2	2.7×10^4	1.4×10^2	1.3×10^4
U-235 + 1 dtr	2.3×10^{-1}	4.8×10^2	2.4×10^4	1.2×10^2	1.2×10^4
U-238 + 2 dtrs	3.6×10^{-1}	7.6×10^2	3.8×10^4	2.0×10^2	1.8×10^4

^aIntakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

^bNA - Not applicable. Radon is a gas.

TABLE E.III-79

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - AIR
ON-PROPERTY RME CHILD UNDER FUTURE LAND USE

Chemical	Concentration (mg/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Arsenic	4.2×10^{-3}	2.3×10^{-5}	1.4×10^{-3}	1.8×10^{-4}	1.7×10^{-4}
Beryllium	3.2×10^{-6}	1.8×10^{-8}	1.0×10^{-6}	9.3×10^{-8}	2.6×10^{-9}
Cadmium	5.7×10^{-6}	3.1×10^{-8}	1.6×10^{-5}	1.0×10^{-6}	5.7×10^{-5}
Chromium	4.0×10^{-5}	2.2×10^{-7}	1.7×10^{-5}	6.1×10^{-6}	5.2×10^{-5}
Nickel	5.7×10^{-5}	3.1×10^{-7}	8.7×10^{-5}	1.9×10^{-5}	9.9×10^{-5}
Aroclor-1248	5.5×10^{-7}	3.0×10^{-9}	1.6×10^{-7}	6.1×10^{-8}	6.0×10^{-7}
Aroclor-1254	5.0×10^{-7}	2.7×10^{-9}	1.5×10^{-7}	2.1×10^{-7}	1.4×10^{-6}
Benzo(a)anthracene	7.1×10^{-8}	3.9×10^{-10}	2.0×10^{-8}	5.3×10^{-9}	5.3×10^{-8}
Benzo(a)pyrene	7.5×10^{-7}	4.1×10^{-9}	2.3×10^{-7}	1.5×10^{-7}	1.5×10^{-6}
Benzo(b)fluoranthene	1.1×10^{-8}	6.0×10^{-11}	3.0×10^{-9}	7.2×10^{-9}	7.1×10^{-8}
Benzo(g,h,i)perylene	3.2×10^{-8}	1.8×10^{-10}	8.8×10^{-9}	9.5×10^{-8}	9.4×10^{-7}
Chrysene	7.3×10^{-8}	4.0×10^{-10}	2.1×10^{-8}	5.7×10^{-9}	5.6×10^{-8}
Indeno(1,2,3-cd)pyrene	2.6×10^{-8}	1.4×10^{-10}	7.1×10^{-9}	2.1×10^{-7}	7.5×10^{-7}
Pentachlorophenol	2.6×10^{-7}	1.4×10^{-9}	7.5×10^{-8}	4.9×10^{-9}	4.8×10^{-8}
Tetrachloroethene	1.2×10^{-7}	6.6×10^{-10}	4.0×10^{-8}	7.9×10^{-12}	7.8×10^{-11}
2,3,7,8-TCDF	3.9×10^{-11}	2.1×10^{-13}	1.1×10^{-11}	5.9×10^{-11}	8.8×10^{-10}
HpCDD	6.3×10^{-10}	3.5×10^{-12}	1.7×10^{-10}	9.5×10^{-10}	1.4×10^{-8}
HpCDF	1.7×10^{-10}	9.3×10^{-13}	4.7×10^{-11}	2.6×10^{-10}	3.8×10^{-9}
HxCDD	5.1×10^{-11}	2.8×10^{-13}	1.4×10^{-10}	7.7×10^{-11}	1.1×10^{-9}
HxCDF	5.3×10^{-11}	2.9×10^{-13}	1.5×10^{-11}	8.0×10^{-11}	1.2×10^{-9}
OCDD	2.5×10^{-9}	1.4×10^{-11}	6.9×10^{-10}	3.8×10^{-9}	5.6×10^{-8}
OCDF	1.5×10^{-10}	8.2×10^{-13}	4.1×10^{-11}	2.3×10^{-10}	3.4×10^{-9}

^aIntakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

TABLE E.III-80

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - AIR
ON-PROPERTY RME CHILD UNDER FUTURE LAND USE

Chemical	Concentration (mg/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Antimony	1.3×10^{-5}	8.3×10^{-7}	7.3×10^{-5}	8.4×10^{-6}	2.6×10^{-5}
Arsenic	4.2×10^{-3}	2.7×10^{-4}	1.6×10^{-2}	2.1×10^{-3}	1.9×10^{-3}
Barium	2.2×10^{-3}	1.4×10^{-4}	1.9×10^{-2}	6.6×10^{-4}	4.8×10^{-2}
Beryllium	3.2×10^{-6}	2.0×10^{-7}	1.2×10^{-5}	1.1×10^{-6}	3.0×10^{-8}
Boron	3.1×10^{-5}	2.0×10^{-6}	9.7×10^{-5}	9.7×10^{-7}	5.6×10^{-5}
Cadmium	5.7×10^{-6}	3.6×10^{-7}	1.9×10^{-4}	1.2×10^{-5}	6.6×10^{-4}
Chromium	4.0×10^{-5}	2.6×10^{-6}	2.0×10^{-4}	7.1×10^{-5}	6.0×10^{-4}
Cobalt	8.4×10^{-6}	5.4×10^{-7}	3.9×10^{-5}	4.9×10^{-5}	1.5×10^{-4}
Copper	5.7×10^{-4}	3.6×10^{-5}	9.0×10^{-3}	4.4×10^{-3}	2.0×10^{-2}
Cyanide	3.2×10^{-7}	2.0×10^{-8}	1.5×10^{-6}	1.2×10^{-12}	1.1×10^{-11}
Lead	1.4×10^{-4}	8.9×10^{-6}	1.1×10^{-3}	4.4×10^{-5}	1.1×10^{-3}
Manganese	3.4×10^{-3}	2.2×10^{-4}	2.3×10^{-2}	9.7×10^{-4}	2.6×10^{-2}
Mercury	6.6×10^{-7}	4.2×10^{-8}	2.6×10^{-6}	3.3×10^{-5}	1.8×10^{-6}
Molybdenum	6.0×10^{-5}	3.8×10^{-6}	3.2×10^{-4}	1.4×10^{-4}	1.1×10^{-3}
Nickel	5.7×10^{-5}	3.6×10^{-6}	1.0×10^{-3}	2.2×10^{-4}	1.2×10^{-3}
Selenium	1.0×10^{-5}	6.4×10^{-7}	9.9×10^{-5}	5.9×10^{-5}	4.9×10^{-4}
Silver	8.7×10^{-6}	5.6×10^{-7}	9.1×10^{-5}	2.8×10^{-5}	5.8×10^{-3}
Thallium	3.3×10^{-6}	2.1×10^{-7}	1.1×10^{-5}	3.6×10^{-5}	5.6×10^{-5}
Tin	3.9×10^{-5}	2.5×10^{-6}	1.5×10^{-4}	6.7×10^{-4}	2.6×10^{-4}

4287

E-III-124

1010

TABLE E.III-80
(Continued)

Chemical	Concentration (mg/m ³)	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Uranium	1.0×10^0	6.4×10^{-2}	3.2×10^0	1.6×10^{-2}	1.5×10^0
Vanadium	1.1×10^{-3}	7.0×10^{-5}	4.6×10^{-3}	6.9×10^{-4}	1.7×10^{-4}
Zinc	6.8×10^{-5}	4.3×10^{-6}	3.1×10^{-2}	1.7×10^{-1}	5.3×10^{-1}

^aIntakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

E-III-125

1011

4282

TABLE E.III-81

INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - SURFACE SOIL
ON-PROPERTY RME CHILD - FOOD INGESTION (PITS 1 & 2)

4787

Radionuclide	Concentration (pCi/g)	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Cs-137 + 1 dtr	1.0×10^0	2.8×10^3	5.4×10^3	5.9×10^4
Np-237 + 1 dtr	5.0×10^{-1}	4.5×10^2	9.1×10^0	2.6×10^1
Pu-238	3.8×10^{-1}	1.6×10^0	6.0×10^{-3}	3.8×10^{-2}
Pu-239/240	1.3×10^{-1}	5.3×10^{-1}	2.1×10^{-3}	1.3×10^{-2}
Ra-226 + 8 dtrs	9.5×10^{-1}	1.3×10^2	1.8×10^1	1.0×10^3
Sr-90 + 1 dtr	1.7×10^0	3.8×10^4	3.8×10^3	6.0×10^5
Tc-99	8.7×10^0	1.2×10^6	2.1×10^6	7.9×10^7
Th-230	7.5×10^1	5.8×10^2	1.5×10^1	3.8×10^2
Th-232 + 10 dtrs	4.3×10^0	3.4×10^1	8.5×10^{-1}	2.3×10^1
U-234	6.0×10^1	2.1×10^4	6.7×10^2	6.2×10^4
U-235 + 1 dtr	6.8×10^0	2.6×10^3	7.9×10^1	7.2×10^3
U-238 + 2 dtrs	2.4×10^2	8.7×10^4	2.7×10^3	2.5×10^5

^aIntakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-17.

4787

TABLE E.III-82
INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL
ON-PROPERTY RME CHILD - FOOD INGESTION

Chemical	Concentration (mg/kg)	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Aroclor-1254	1.40×10^0	5.7×10^{-6}	1.6×10^{-5}	1.0×10^{-4}
Arsenic	4.90×10^0	7.0×10^{-6}	3.9×10^{-6}	3.6×10^{-6}
Beryllium	8.00×10^{-1}	2.9×10^{-7}	1.3×10^{-7}	3.6×10^{-9}

^aIntakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-17.

TABLE E.III-83
INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL
ON-PROPERTY RME CHILD - FOOD INGESTION

4787

Chemical	Concentration (mg/kg)	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Antimony	2.72×10^1	2.3×10^{-3}	5.3×10^{-4}	1.6×10^{-3}
Arsenic	4.90×10^0	8.2×10^{-5}	4.5×10^{-5}	4.2×10^{-5}
Barium	5.69×10^1	2.4×10^{-3}	1.3×10^{-4}	9.2×10^{-3}
Beryllium	8.00×10^{-1}	3.3×10^{-6}	1.5×10^{-6}	4.1×10^{-8}
Cadmium	5.80×10^0	2.4×10^{-3}	1.7×10^{-4}	9.3×10^{-3}
Chromium	1.43×10^1	1.8×10^{-4}	1.3×10^{-4}	1.1×10^{-3}
Cobalt	1.04×10^1	2.0×10^{-5}	5.8×10^{-4}	1.8×10^{-3}
Copper	1.70×10^1	1.2×10^{-2}	6.5×10^{-3}	3.0×10^{-2}
Lead	1.59×10^1	4.0×10^{-4}	2.4×10^{-5}	6.3×10^{-4}
Manganese	5.74×10^2	8.0×10^{-2}	5.5×10^{-3}	1.5×10^{-1}
Molybdenum	4.30×10^0	7.2×10^{-4}	6.2×10^{-4}	4.8×10^{-3}
Nickel	2.94×10^1	4.9×10^{-3}	1.1×10^{-3}	5.9×10^{-3}
Silver	8.90×10^0	2.5×10^{-3}	1.0×10^{-3}	2.1×10^{-1}
Uranium	5.20×10^1	5.8×10^{-4}	1.8×10^{-5}	1.7×10^{-3}
Vanadium	1.96×10^1	1.6×10^{-4}	7.0×10^{-5}	1.7×10^{-5}
Zinc	4.67×10^1	1.2×10^{-1}	6.5×10^{-1}	2.0×10^0

^aIntakes calculated using concentrations in Table E.3-3 and exposure factors in Table E.3-17.

4787

TABLE E.III-84

INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - SURFACE SOIL/EXPOSED PIT CONTENTS
ON-PROPERTY RME CHILD UNDER FUTURE LAND USE

Radionuclide	Concentration (pCi/g)	Ingestion of Soil
Cs-137 + 1 dtr	4.7×10^0	2.0×10^3
Np-237 + 1 dtr	2.9×10^0	1.2×10^3
Pu-238	6.3×10^{-1}	2.6×10^2
Pu-239/240	2.6×10^0	1.1×10^3
Ra-226 + 8 dtrs	4.9×10^1	2.1×10^4
Sr-90 + 1 dtr	3.1×10^0	1.3×10^3
Tc-99	1.8×10^2	7.6×10^4
Th-230	1.6×10^3	6.7×10^5
Th-232 + 10 dtrs	6.2×10^1	2.6×10^4
U-234	2.9×10^2	1.2×10^5
U-235 + 1 dtr	3.5×10^1	1.5×10^4
U-238 + 2 dtrs	6.2×10^2	2.6×10^5

^aIntakes calculated using concentrations in Table E.3-4 and exposure factors in Table E.3-17.

TABLE E.III-85

4787

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL/EXPOSED PIT MATERIALS
ON-PROPERTY RME CHILD UNDER FUTURE LAND USE

Chemical	Concentration (mg/kg)	Ingestion of Soil	Dermal Contact
Aroclor-1248	4.08×10^{-1}	4.5×10^{-7}	1.2×10^{-6}
Aroclor-1254	1.46×10^0	1.6×10^{-6}	4.3×10^{-6}
Arsenic	3.09×10^3	3.4×10^{-3}	3.0×10^{-5}
Beryllium	3.41×10^0	3.8×10^{-6}	3.4×10^{-7}
Benzo(a)anthracene	5.04×10^{-2}	5.5×10^{-8}	5.0×10^{-7}
Benzo(a)pyrene	3.92×10^{-2}	4.3×10^{-8}	3.9×10^{-7}
Benzo(b)fluoranthene	7.84×10^{-2}	8.6×10^{-8}	1.5×10^{-7}
Chrysene	5.18×10^{-2}	5.7×10^{-8}	5.1×10^{-7}
Indeno(1,2,3-cd)pyrene	1.82×10^{-2}	2.0×10^{-8}	1.8×10^{-8}
Pentachlorophenol	1.82×10^{-1}	2.0×10^{-7}	1.8×10^{-6}
Tetrachloroethene	2.72×10^{-1}	3.0×10^{-7}	1.1×10^{-6}
2,3,7,8-TCDF	2.80×10^{-5}	3.1×10^{-11}	2.8×10^{-10}
HpCDD	2.94×10^{-4}	3.2×10^{-10}	2.9×10^{-9}
HpCDF	1.26×10^{-4}	1.4×10^{-10}	1.2×10^{-9}
HxCDD	4.31×10^{-5}	4.7×10^{-11}	4.2×10^{-10}
HxCDF	3.74×10^{-5}	4.1×10^{-11}	3.7×10^{-10}
OCDD	1.78×10^{-3}	2.0×10^{-9}	1.8×10^{-8}
OCDF	1.04×10^{-4}	1.1×10^{-10}	1.0×10^{-9}

^aIntakes calculated using concentrations in Table E.3-4 and exposure factors in Table E.3-17.

4787

TABLE E.III-86

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL/EXPOSED PIT MATERIALS
ON-PROPERTY RME CHILD UNDER FUTURE LAND USE

Chemical	Concentration (mg/kg)	Ingestion of Soil	Dermal Contact
Antimony	3.17×10^1	4.1×10^{-4}	3.6×10^{-5}
Arsenic	3.09×10^3	4.0×10^{-2}	3.6×10^{-4}
Barium	2.59×10^3	3.3×10^{-2}	3.0×10^{-3}
Beryllium	3.41×10^0	4.4×10^{-5}	3.9×10^{-6}
Boron	2.17×10^1	2.8×10^{-4}	2.5×10^{-5}
Cadmium	8.90×10^0	1.1×10^{-4}	1.0×10^{-5}
Chromium	4.33×10^1	5.5×10^{-4}	5.0×10^{-5}
Cobalt	1.53×10^1	2.0×10^{-4}	1.8×10^{-5}
Copper	8.13×10^2	1.0×10^{-2}	9.3×10^{-5}
Cyanide	2.25×10^{-1}	2.9×10^{-6}	2.6×10^{-7}
Lead	1.16×10^2	1.5×10^{-3}	1.3×10^{-4}
Manganese	2.95×10^3	3.8×10^{-2}	3.4×10^{-3}
Mercury	5.22×10^{-1}	6.7×10^{-6}	3.0×10^{-6}
Molybdenum	6.84×10^1	8.8×10^{-4}	7.9×10^{-5}
Nickel	6.85×10^1	8.8×10^{-4}	3.9×10^{-6}
Selenium	7.58×10^0	9.7×10^{-5}	8.7×10^{-6}
Silver	1.46×10^1	1.9×10^{-4}	1.7×10^{-5}
Thallium	3.96×10^0	5.1×10^{-5}	4.6×10^{-6}
Tin	2.90×10^1	3.7×10^{-4}	3.3×10^{-6}
Uranium	9.89×10^2	1.3×10^{-2}	1.1×10^{-3}
Vanadium	9.75×10^2	1.3×10^{-2}	1.1×10^{-4}
Zinc	9.13×10^1	1.2×10^{-3}	1.1×10^{-4}
Pentachlorophenol	1.82×10^{-1}	2.3×10^{-6}	2.1×10^{-5}
Tetrachloroethene	2.72×10^{-1}	3.5×10^{-6}	1.3×10^{-5}

^aIntakes calculated using concentrations in Table E.3-4 and exposure factors in Table E.3-17.

TABLE E.III-87
INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - SURFACE WATER
ON-PROPERTY RME RESIDENT CHILD UNDER FUTURE LAND USE

787

Radionuclide	Concentration (pCi/L)	Ingestion of Meat	Ingestion of Milk
Cs-137 + 1 dtr	5.6×10^1	3.4×10^3	4.5×10^4
Ra-226 + 8 dtrs	2.5×10^{-1}	1.9×10^{-1}	1.3×10^1
Sr-90 + 1 dtr	2.6×10^1	2.4×10^1	4.3×10^3
Tc-99	1.5×10^3	3.9×10^4	1.7×10^6
Th-230	1.9×10^{-1}	3.5×10^{-3}	1.1×10^{-1}
U-234	7.1×10^2	4.3×10^2	4.9×10^4
U-235 + 1 dtr	4.0×10^1	2.4×10^1	2.6×10^3
U-238 + 2 dtrs	1.7×10^3	1.0×10^3	1.2×10^5

^aIntakes calculated using concentrations in Table E.3-10 and exposure factors in Table E.3-17.

1018

TABLE E.III-88

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE WATER
ON-PROPERTY RME RESIDENT CHILD UNDER FUTURE LAND USE

Chemical	Concentration (mg/L)	Ingestion of Meat	Ingestion of Milk
Arsenic	2.3×10^{-3}	5.5×10^{-7}	5.1×10^{-7}
Benzene	6.9×10^{-3}	2.6×10^{-9}	2.6×10^{-8}

^aIntakes calculated using concentrations in Table E.3-10 and exposure factors in Table E.3-17.

1019

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TABLE E.III-89
INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE WATER
ON-PROPERTY RME RESIDENT CHILD UNDER FUTURE LAND USE

Chemical	Concentration (mg/L)	Ingestion of Meat	Ingestion of Milk
Antimony	3.0×10^{-3}	1.2×10^{-5}	3.7×10^{-5}
Arsenic	2.3×10^{-3}	6.3×10^{-6}	6.0×10^{-6}
Barium	6.8×10^{-2}	1.2×10^{-4}	8.7×10^{-3}
Copper	1.8×10^{-2}	8.5×10^{-4}	4.0×10^{-3}
Cyanide	7.6×10^{-2}	6.1×10^{-10}	6.8×10^{-9}
Lead	2.2×10^{-3}	3.7×10^{-6}	9.5×10^{-5}
Nickel	1.3×10^{-2}	2.8×10^{-4}	1.5×10^{-3}
Selenium	2.0×10^{-3}	5.8×10^{-5}	4.9×10^{-4}
Silver	3.2×10^{-3}	6.3×10^{-5}	6.3×10^{-1}
Vanadium	1.5×10^{-1}	3.5×10^{-4}	8.7×10^{-5}
Zinc	9.6×10^{-2}	1.5×10^0	4.7×10^0

^aIntakes calculated using concentrations in Table E.3-10 and exposure factors in Table E.3-17.

787

TABLE E.III-90
INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - GROUNDWATER
ON-PROPERTY RME CHILD UNDER FUTURE LAND USE

Radionuclide	Concentration (pCi/L)	Ingestion of Water	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Np-237 + 1 dtr	1.2×10^{-4}	3.5×10^{-1}	1.4×10^{-1}	2.2×10^{-4}	6.4×10^{-4}
Pu-238	1.3×10^{-1}	3.8×10^2	1.4×10^2	1.2×10^{-3}	7.6×10^{-3}
Ra-226 + 8 dtrs	1.8×10^0	5.3×10^3	2.1×10^3	1.9×10^1	1.1×10^3
Sr-90 + 1 dtr	4.7×10^{-3}	1.4×10^1	6.6×10^0	1.1×10^{-1}	1.7×10^1
Tc-99	1.6×10^1	4.7×10^4	1.7×10^4	3.3×10^3	1.2×10^5
Th-230	1.0×10^0	2.9×10^3	1.1×10^3	1.3×10^{-1}	3.4×10^0
U-234	8.8×10^2	2.6×10^6	9.2×10^5	3.2×10^3	3.0×10^5
U-235 + 1 dtr	2.0×10^2	5.9×10^5	2.1×10^5	6.7×10^2	6.8×10^4
U-238 + 2 dtrs	4.2×10^3	1.2×10^7	4.5×10^6	1.5×10^4	1.5×10^6

^aIntakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

1021

TABLE E.III-91

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - GROUNDWATER
ON-PROPERTY RME CHILD UNDER FUTURE LAND USE

Chemical	Concentration (mg/L)	Ingestion of Water	Inhalation	Dermal Contact	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Arsenic	5.82×10^{-1}	4.5×10^{-3}	0.0×10^0	7.6×10^{-6}	2.0×10^{-3}	1.4×10^{-4}	1.3×10^{-4}

^aIntakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

E-III-136

1002

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TABLE E.III-92

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - GROUNDWATER
ON-PROPERTY RME CHILD UNDER FUTURE LAND USE

Chemical	Concentration (mg/L)	Ingestion of Water	Inhalation	Dermal Contact	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Antimony	1.75×10^{-1}	1.6×10^{-2}	0.0×10^0	2.7×10^{-5}	1.1×10^{-2}	6.8×10^{-4}	2.1×10^{-3}
Arsenic	5.82×10^{-1}	5.2×10^{-2}	0.0×10^0	8.8×10^{-5}	2.3×10^{-2}	1.6×10^{-3}	1.5×10^{-3}
Barium	6.51×10^{-1}	5.8×10^{-2}	0.0×10^0	9.9×10^{-5}	6.5×10^{-2}	1.2×10^{-3}	8.3×10^{-2}
Boron	3.08×10^{-2}	2.8×10^{-3}	0.0×10^0	4.7×10^{-6}	9.7×10^{-4}	2.6×10^{-6}	1.8×10^{-4}
Cyanide	4.22×10^{-6}	3.8×10^{-7}	0.0×10^0	6.4×10^{-10}	2.1×10^{-7}	3.4×10^{-14}	3.8×10^{-13}
Lead	5.80×10^{-2}	5.2×10^{-3}	0.0×10^0	8.8×10^{-6}	5.3×10^{-3}	9.6×10^{-5}	2.5×10^{-3}
Manganese	2.07×10^0	1.9×10^{-1}	0.0×10^0	3.1×10^{-4}	1.6×10^{-1}	3.6×10^{-3}	9.8×10^{-2}
Uranium	1.26×10^1	1.1×10^0	0.0×10^0	1.9×10^{-3}	4.0×10^{-1}	1.3×10^{-3}	1.3×10^{-1}

^aIntakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

TABLE E.III-93
INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - PERCHED WATER
ON-PROPERTY RME CHILD UNDER FUTURE LAND USE

Radionuclides	Concentration (pCi/L)	Ingestion
Cs-137 + 1 dtr	9.0×10^0	2.6×10^5
Np-237 + 1 dtr	7.5×10^0	2.2×10^4
Pu-238	4.9×10^{-1}	1.4×10^3
Pu-239/240	5.0×10^{-2}	1.5×10^2
Ra-226 + 8 dtrs	7.2×10^1	2.1×10^5
Sr-90 + 1 dtr	4.0×10^1	1.2×10^5
Tc-99	2.7×10^3	7.9×10^6
Th-230	3.0×10^{-1}	8.8×10^2
Th-232 + 10 dtrs	5.1×10^{-2}	1.5×10^2
U-234	1.5×10^5	4.4×10^8
U-235 + 1 dtr	2.8×10^4	8.2×10^7
U-238 + 2 dtrs	4.3×10^5	1.3×10^9

^aIntakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

4787

TABLE E.III-94

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - PERCHED WATER
ON-PROPERTY RME CHILD UNDER FUTURE LAND USE

Chemical	Concentration (mg/L)	Ingestion
Arsenic	6.32×10^{-1}	4.8×10^{-3}
Beryllium	2.04×10^{-2}	1.6×10^{-4}
Tetrachloroethene	1.40×10^{-1}	1.1×10^{-3}
Vinyl chloride	1.00×10^0	7.7×10^{-3}
Pentachlorophenol	2.00×10^{-1}	1.5×10^{-3}
Aroclor-1248	5.00×10^{-2}	3.8×10^{-4}
Aroclor-1254	1.00×10^{-1}	7.7×10^{-4}
Benzo(a)anthracene	4.00×10^{-2}	3.1×10^{-4}
Benzo(a)pyrene	4.00×10^{-2}	3.1×10^{-4}
Benzo(b)fluoranthene	4.00×10^{-2}	3.1×10^{-4}
Benzo(k)fluoranthene	4.00×10^{-2}	3.1×10^{-4}
Chrysene	4.00×10^{-2}	3.1×10^{-4}
Dibenzo(a,h)anthracene	1.00×10^{-2}	7.7×10^{-5}
Indeno(1,2,3-cd)pyrene	4.00×10^{-2}	3.1×10^{-4}
2,3,7,8-TCDF	5.30×10^{-6}	4.1×10^{-8}
HpCDD	9.40×10^{-7}	7.2×10^{-9}
HpCDF	2.00×10^{-6}	1.5×10^{-8}
HxCDD	7.50×10^{-7}	5.8×10^{-9}
HxCDF	1.20×10^{-6}	9.2×10^{-9}
OCDD	1.80×10^{-6}	1.4×10^{-8}
OCDF	1.10×10^{-6}	8.4×10^{-8}
1,2,3,7,8-PeCDF	1.00×10^{-6}	7.7×10^{-9}
2,3,4,7,8-PeCDF	1.10×10^{-6}	8.4×10^{-9}

^aIntakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

TABLE E.III-95
INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - PERCHED WATER
ON-PROPERTY RME CHILD UNDER FUTURE LAND USE

4787

Chemical	Concentration (mg/L)	Ingestion
Antimony	9.56×10^{-1}	8.6×10^{-2}
Arsenic	6.32×10^{-1}	5.7×10^{-2}
Barium	1.96×10^0	1.8×10^{-1}
Beryllium	2.04×10^{-2}	1.8×10^{-3}
Boron	2.93×10^0	2.6×10^{-1}
Cadmium	1.18×10^{-1}	1.1×10^{-2}
Chromium	1.29×10^{-1}	1.2×10^{-2}
Cobalt	3.38×10^{-1}	3.0×10^{-2}
Copper	9.48×10^{-1}	8.5×10^{-2}
Cyanide	3.60×10^0	3.2×10^{-1}
Lead	6.91×10^{-1}	6.2×10^{-2}
Manganese	2.41×10^0	2.2×10^{-1}
Mercury	2.18×10^{-2}	2.0×10^{-3}
Molybdenum	1.15×10^2	1.0×10^1
Nickel	2.13×10^0	1.9×10^{-1}
Selenium	3.80×10^{-3}	3.4×10^{-4}
Silver	6.67×10^{-2}	6.0×10^{-3}
Thallium	7.54×10^{-1}	6.7×10^{-2}
Tin	8.29×10^0	7.4×10^{-1}
Uranium	5.00×10^2	4.5×10^1
Vanadium	1.44×10^0	1.3×10^{-1}
Zinc	1.79×10^0	1.6×10^{-1}
Acenaphthene	4.00×10^{-2}	3.6×10^{-3}
Anthracene	4.00×10^{-2}	3.6×10^{-3}
Fluoranthene	4.00×10^{-2}	3.6×10^{-3}
Fluorene	4.00×10^{-2}	3.6×10^{-3}
Naphthalene	1.60×10^{-2}	1.4×10^{-3}
Phenanthrene	4.00×10^{-2}	3.6×10^{-3}
Pyrene	4.00×10^{-2}	3.6×10^{-3}

4787

TABLE E.III-95
(Continued)

Chemical	Concentration (mg/L)	Ingestion
4-Nitrophenol	1.00×10^{-2}	9.0×10^{-4}
Pentachlorophenol	2.00×10^{-1}	1.8×10^{-2}
Tetrachloroethene	1.40×10^{-1}	1.3×10^{-2}

*Intakes calculated using concentrations in Table E.3-13 and exposure factors in Table E.3-17.

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TABLE E.III-96
INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - AIR
ON-PROPERTY HOME BUILDER UNDER FUTURE LAND USE

4787

Radionuclide	Concentration (pCi/m ³)	Inhalation
Cs-127 + dtr	1.6×10^{-3}	3.3×10^{-1}
Np-237 + dtr	1.3×10^{-3}	2.7×10^{-1}
Pu-238	2.9×10^{-4}	6.0×10^{-2}
Pu-239/40	3.0×10^{-3}	6.2×10^{-1}
Ra-226 & Pb-210 + 2 dtrs	6.3×10^{-2}	1.3×10^1
Rn-222 + 4 dtrs	4.8×10^2	1.0×10^5
Tc-99	1.4×10^{-1}	2.9×10^1
Th-230	1.8×10^0	3.7×10^2
Th-232 + 10 dtrs	8.0×10^{-2}	1.7×10^1
U-234	2.6×10^{-1}	5.4×10^1
U-235 + 1 dtr	2.3×10^{-1}	4.8×10^1
U-238 + 2 dtrs	3.6×10^{-1}	7.5×10^1

^aIntakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3.17.

1028

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TABLE E.III-97

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)^a
FUTURE CONDITIONS - AIR
ON-PROPERTY HOME BUILDER UNDER FUTURE LAND USE

Radionuclide	Concentration (mg/m ³)	Inhalation
Arsenic	4.2×10^{-3}	4.9×10^{-7}
Beryllium	3.2×10^{-6}	3.7×10^{-10}
Cadmium	5.7×10^{-6}	6.6×10^{-10}
Chromium	4.0×10^{-5}	4.6×10^{-9}
Nickel	5.7×10^{-5}	6.6×10^{-9}
Benzo(a)pyrene	7.5×10^{-7}	8.7×10^{-11}
Benzo(a)anthracene	7.1×10^{-8}	8.2×10^{-12}
Benzo(b)fluoranthene	1.1×10^{-8}	1.3×10^{-12}
Chrysene	7.3×10^{-8}	8.5×10^{-12}
Indeno(1,2,3-cd)pyrene	2.6×10^{-8}	3.0×10^{-12}
Pentachlorophenol	2.6×10^{-7}	3.0×10^{-11}
Tetrachloroethene	1.2×10^{-7}	1.4×10^{-11}
2,3,7,8-TCDF	3.9×10^{-11}	4.5×10^{-15}
HpCDD	6.3×10^{-10}	7.3×10^{-14}
HpCDF	1.7×10^{-10}	2.0×10^{-14}
HxCDD	5.1×10^{-11}	5.9×10^{-15}
HxCDF	5.3×10^{-11}	6.1×10^{-15}
OCDD	2.5×10^{-9}	2.9×10^{-13}
OCDF	1.5×10^{-10}	1.7×10^{-14}

^a Intakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

1029

TABLE E.III-98
INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - AIR
ON-PROPERTY HOME BUILDER UNDER FUTURE LAND USE

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Chemical	Concentration (mg/m ³)	Inhalation
Antimony	1.3 x 10 ⁻⁵	1.1 x 10 ⁻⁷
Arsenic	4.2 x 10 ⁻³	3.4 x 10 ⁻⁵
Barium	2.2 x 10 ⁻³	1.8 x 10 ⁻⁵
Beryllium	3.2 x 10 ⁻⁶	2.6 x 10 ⁻⁸
Boron	3.1 x 10 ⁻⁵	2.5 x 10 ⁻⁷
Cadmium	5.7 x 10 ⁻⁶	4.6 x 10 ⁻⁸
Chromium	4.0 x 10 ⁻⁵	3.2 x 10 ⁻⁷
Cobalt	8.4 x 10 ⁻⁶	6.8 x 10 ⁻⁸
Copper	5.7 x 10 ⁻⁴	4.6 x 10 ⁻⁶
Cyanide	3.2 x 10 ⁻⁷	2.6 x 10 ⁻⁹
Lead	1.4 x 10 ⁻⁴	1.1 x 10 ⁻⁶
Manganese	3.4 x 10 ⁻³	2.8 x 10 ⁻⁵
Mercury	6.6 x 10 ⁻⁷	5.4 x 10 ⁻⁹
Molybdenum	6.0 x 10 ⁻⁵	4.9 x 10 ⁻⁷
Nickel	5.7 x 10 ⁻⁵	4.6 x 10 ⁻⁷
Selenium	1.0 x 10 ⁻⁵	8.1 x 10 ⁻⁸
Silver	8.7 x 10 ⁻⁶	7.1 x 10 ⁻⁸
Thallium	3.3 x 10 ⁻⁶	2.7 x 10 ⁻⁸
Tin	3.9 x 10 ⁻⁵	3.2 x 10 ⁻⁷
Uranium	1.0 x 10 ⁰	8.1 x 10 ⁻³
Vanadium	1.1 x 10 ⁻³	8.9 x 10 ⁻⁶
Zinc	6.8 x 10 ⁻⁵	5.5 x 10 ⁻⁷

^aIntakes calculated using concentrations in Table E.3-15 and exposure factors in Table E.3-17.

1030

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TABLE E.III-99
INTAKES - RADIONUCLIDES (pCi)^a
FUTURE CONDITIONS - SURFACE SOIL/EXPOSED PIT CONTENTS
ON-PROPERTY HOME BUILDER UNDER FUTURE LAND USE

Radionuclide	Concentration (pCi/g)	Ingestion of Soil	External Exposure (pCi-yr/g)
Np-237 + 1 dtr	4.0×10^{-1}	9.6×10^0	1.7×10^{-2}
Pu-238	5.0×10^{-1}	1.2×10^1	2.1×10^{-2}
Pu-239/240	4.0×10^{-1}	9.6×10^0	1.7×10^{-2}
Ra-226 + 8 dtrs	3.7×10^1	8.9×10^2	1.6×10^0
Sr-90 + 1 dtr	9.9×10^1	2.4×10^3	4.2×10^0
Tc-99	2.0×10^2	4.8×10^3	8.6×10^0
Th-230	1.5×10^3	3.6×10^4	6.4×10^1
Th-232	7.1×10^2	1.7×10^4	3.0×10^1
U-234	4.1×10^3	9.8×10^4	1.8×10^2
U-235 +1 dtr	9.0×10^2	2.2×10^4	3.9×10^1
U-238 + 2 dtrs	4.4×10^4	1.1×10^6	1.9×10^3

^aIntakes calculated using concentrations in Table E.3-5 and exposure factors in Table E.3-17.

TABLE E.III-100

INTAKES - CHEMICAL CARCINOGENS (mg/kg/day)*
FUTURE CONDITIONS - SURFACE SOIL/EXPOSED PIT CONTENTS
ON-PROPERTY HOME BUILDER UNDER FUTURE LAND USE

4787

Chemical	Concentration (mg/kg)	Ingestion of Soil	Dermal Contact
Aroclor-1242	1.03×10^0	1.4×10^{-8}	4.3×10^{-8}
Aroclor-1248	5.92×10^0	7.9×10^{-8}	2.5×10^{-7}
Aroclor-1254	6.80×10^0	9.1×10^{-8}	2.8×10^{-7}
Arsenic	5.16×10^0	6.9×10^{-8}	7.2×10^{-10}
Beryllium	5.06×10^1	6.8×10^{-7}	7.1×10^{-8}
Benzo(a)anthracene	4.70×10^0	6.3×10^{-8}	6.6×10^{-7}
Benzo(a)pyrene	4.50×10^0	6.0×10^{-8}	6.3×10^{-7}
Benzo(b)fluoranthene	5.20×10^0	7.0×10^{-8}	1.5×10^{-7}
Benzo(k)fluoranthene	3.70×10^0	5.0×10^{-8}	1.0×10^{-7}
Chrysene	3.86×10^0	5.2×10^{-8}	5.4×10^{-7}
Indeno(1,2,3-cd)pyrene	9.90×10^1	1.3×10^{-8}	1.4×10^{-8}
Tetrachloroethene	3.00×10^1	4.0×10^{-7}	1.7×10^{-6}
TCDD	4.70×10^{-4}	6.3×10^{-12}	6.6×10^{-11}
TCDF	3.11×10^{-2}	4.2×10^{-10}	4.4×10^{-9}
HpCDD	3.16×10^{-3}	4.2×10^{-11}	4.4×10^{-10}
HpCDF	5.58×10^{-3}	7.5×10^{-11}	7.8×10^{-10}
HxCDD	2.29×10^{-3}	3.1×10^{-11}	3.2×10^{-10}
HxCDF	9.58×10^{-3}	1.3×10^{-10}	1.3×10^{-9}
OCDD	6.52×10^{-3}	8.7×10^{-11}	9.1×10^{-10}
OCDF	3.66×10^{-3}	4.9×10^{-11}	5.1×10^{-10}
1,2,3,7,8-PeCDF	1.39×10^{-3}	1.9×10^{-11}	1.9×10^{-10}
2,3,4,7,8-PeCDF	1.12×10^{-2}	1.5×10^{-10}	1.6×10^{-9}

*Intakes calculated using concentrations in Table E.3-5 and exposure factors in Table E.3-17.

TABLE E.III-101

INTAKES - TOXIC CHEMICALS (mg/kg/day)^a
FUTURE CONDITIONS - SURFACE SOIL/EXPOSED PIT CONTENTS
ON-PROPERTY HOME BUILDER UNDER FUTURE LAND USE

Chemical	Concentration (mg/kg)	Dermal Contact	Ingestion
Antimony	2.22×10^2	2.2×10^{-5}	2.1×10^{-4}
Arsenic	5.16×10^0	5.0×10^{-8}	4.8×10^{-6}
Barium	4.58×10^3	4.5×10^{-7}	4.3×10^{-3}
Beryllium	5.06×10^1	4.9×10^{-6}	4.7×10^{-5}
Boron	6.58×10^2	6.4×10^{-5}	6.1×10^{-4}
Cadmium	2.45×10^1	2.4×10^{-6}	2.3×10^{-5}
Chromium	1.05×10^3	1.0×10^{-4}	9.8×10^{-4}
Cobalt	1.29×10^2	1.3×10^{-5}	1.2×10^{-4}
Copper	3.52×10^2	3.4×10^{-6}	3.3×10^{-4}
Lead	5.53×10^1	5.4×10^{-6}	5.2×10^{-5}
Manganese	4.75×10^3	4.6×10^{-4}	4.4×10^{-3}
Molybdenum	6.98×10^1	6.8×10^{-6}	6.5×10^{-5}
Nickel	1.67×10^2	8.2×10^{-7}	1.6×10^{-4}
Silver	5.31×10^2	5.2×10^{-5}	5.0×10^{-4}
Tin	1.14×10^2	1.1×10^{-6}	1.1×10^{-4}
Uranium	9.40×10^4	9.2×10^{-3}	8.8×10^{-2}
Vanadium	3.94×10^2	3.9×10^{-6}	3.7×10^{-4}
Zinc	1.43×10^2	1.4×10^{-5}	1.3×10^{-4}
Acenaphthene	1.90×10^0	1.3×10^{-5}	1.8×10^{-6}
Anthracene	2.70×10^0	1.1×10^{-5}	2.5×10^{-6}
Fluoranthene	1.10×10^1	3.2×10^{-5}	1.0×10^{-5}
Fluorene	2.20×10^0	1.5×10^{-5}	2.1×10^{-6}
Naphthalene	1.10×10^0	1.1×10^{-5}	1.0×10^{-6}
Pyrene	9.00×10^0	2.6×10^{-5}	8.4×10^{-6}
4-Nitrophenol	2.30×10^0	6.8×10^{-6}	2.1×10^{-6}
Tetrachloroethene	3.00×10^1	1.2×10^{-4}	2.8×10^{-5}
Tributyl phosphate	7.2×10^1	2.1×10^{-4}	6.7×10^{-5}

^a Intakes calculated using concentrations in Table E.3-5 and exposure factors in Table E.3-17.

LIST OF TABLES

<u>Table</u>	<u>Title</u>	<u>Page</u>
E.IV-1	ILCR for the Trespassing Child, Current Land Use Without Access Control, Current Source Term	E-IV-2
E.IV-2	Hazard Quotients for the Trespassing Child, Current Land Use Without Access Controls, Current Source Term	E-IV-3
E.IV-3	ILCR for the Visitor, Current Land Use With Access Control Current Source Term	E-IV-4
E.IV-4	Hazard Quotients for the Visitor, Current Land Use With Access Controls, Current Source Term	E-IV-5
E.IV-5	ILCR for the Off-Property Farmer (RME), All Land Use, Current Source Term	E-IV-6
E.IV-6	Hazard Quotient for the Off-Property Farmer, All Land Use, Current Source Term	E-IV-7
E.IV-7	ILCR for the Off-Property User of Meat and Dairy Products, Current Land Use, Current Source Term	E-IV-8
E.IV-8	Hazard Quotients for the Off-Property User of Meat and Dairy Products, Current Land Use, Current Source Term	E-IV-9
E.IV-9	ILCR for the Trespassing Child, Current Land Use Without Access Control, Future Source Term	E-IV-10
E.IV-10	Hazard Quotient for the Trespassing Child, Current Land Use, Future Source Term	E-IV-12
E.IV-11	ILCR for the Off-Property Farmer, All Land Use Without Access Control Future Source Term	E-IV-13
E.IV-12	Hazard Quotients for the Off-Property Farmer, All Land Uses, Future Source Term	E-IV-15
E.IV-13	ILCR for the Great Miami River User, Current Land Use, Future Conditions	E-IV-16
E.IV-14	ILCR for the Off-Property User of Meat and Dairy Products, Current Land Use, Future Source Term	E-IV-17
E.IV-15	Hazard Quotients for the Off-Property User of Meat and Dairy Products, Current Land Use, Future Source Term	E-IV-18
E.IV-16	ILCR for the On-Property Resident Farmer, Future Land Use, Future Source Term	E-IV-19
E.IV-17	Hazard Quotient for the On-Property Farmer (RME), Future Land Use, Future Source Term	E-IV-21
E.IV-18	ILCR for the On-Property Resident Farmer (CT), Future Land Use, Future Source Term	E-IV-22
E.IV-19	Hazard Quotients for the On-Property Farmer (CT), Future Land Use, Future Source Term	E-IV-24
E.IV-20	ILCR for the On-Property Resident Child, Future Land Use, Future Source Term	E-IV-25

LIST OF TABLES
(Continued)

<u>Table</u>	<u>Title</u>	<u>Page</u>
E.IV-21	Hazard Quotients for the On-Property Resident Child, Future Land Use, Future Source Term	E-IV-27
E.IV-22	ILCR for the On-Property Home Builder, Future Land Use, Future Source Term	E-IV-29
E.IV-23	Hazard Quotients for the On-Property Home Builder, Future Land Use, Future Source Term	E-IV-31
E.IV-24	ILCR for the On-Property Adult (RME) Perched Groundwater User, Future Land Use, Future Source Term	E-IV-32
E.IV-25	Hazard Quotients for the On-Property Adult (RME) Perched Groundwater User, Future Land Use, Future Source Term	E-IV-34
E.IV-26	ILCR for the On-Property Adult (CT) Perched Groundwater User, Future Land Use, Future Conditions	E-IV-35
E.IV-27	Hazard Quotients for the On-Property Adult (CT) Perched Groundwater User, Future Land Use, Future Source Term	E-IV-36
E.IV-28	ILCR for the On-Property Child Perched Groundwater User, Future Land Use, Future Conditions	E-IV-37
E.IV-29	Hazard Quotients for the On-Property Child Perched Groundwater User, Future Land Use, Future Source Term	E-IV-38
E.IV-30	Risks from Penetrating Radiation, Current Conditions - Buried Pit Material, Trespassing Child Under Current Land Use Without Access Controls	E-IV-39
E.IV-31	Risks from Penetrating Radiation, Current Conditions - Buried Pit Material, Visitor Under Current Land Use With Access Controls	E-IV-40
E.IV-32	Risks from Penetrating Radiation, Future Conditions - Buried Pit Material, Trespassing Child Under Current land Use Without Access Controls	E-IV-41
E.IV-33	Risks from Penetrating Radiation, Future Conditions - Buried Pit Material, On-Property RME Adult Under Future Land Use	E-IV-42
E.IV-34	Risks from Penetrating Radiation, Future Conditions - Buried Pit Material, On-Property CT Adult Under Future Land Use	E-IV-43
E.IV-35	Risks from Penetrating Radiation, Future Conditions - Buried Pit Material, On-Property Child Under Future Land Use	E-IV-44
E.IV-36	Risks from Penetrating Radiation, Future Conditions - Buried Pit Material, On-Property Home Builder Under Future Land Use	E-IV-45

October 12, 1993

**ATTACHMENT E.IV
RISK CALCULATION RESULTS**

4787

This section presents the risk calculation results for the Baseline Risk Assessment for Operable Unit 1. The methodologies used for calculation of cancer risks and hazard quotients was presented in Appendix E, Sections E.2 through E.5. Example calculations and intakes used for calculation of cancer risks and hazard quotients are presented in Attachment E.III. Cancer risks and hazard quotients are provided separately by receptor, source, exposure pathway, and chemical. Within each table, cancer risks or hazard quotients are summed to calculate the incremental lifetime cancer risk (ILCR) or total hazard index for that receptor.

1776

TABLE E.IV-1
ILCR FOR THE TRESPASSING CHILD, CURRENT LAND USE WITHOUT ACCESS CONTROL
CURRENT SOURCE TERM

Transfer Media>>
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Note: ^aRisks calculated using intakes in Table E.III-2 and dose-response parameters in Table E.4-1.
^bRisks calculated using intakes in Table E.III-5 and dose-response parameters in Table E.4-1.
^cRisk calculations for this exposure pathway are presented in Table E.IV-30.
^dRisks calculated using intakes in Table E.III-3 and dose-response parameters in Table E.4-2.
^eRisks calculated using intakes in Table E.III-6 and dose-response parameters in Table E.4-2 and E.4-3.
^fNA - Not Applicable. Exposure route not evaluated for constituent.

TABLE E.IV-2

**HAZARD QUOTIENTS FOR THE TRESPASSING CHILD, CURRENT LAND USE WITHOUT ACCESS CONTROLS
CURRENT SOURCE TERM**

Transfer Media>>>>>>>>	Air	Soil	
Exposure Route>>>>>>>>	Inhalation	Ingestion	Dermal Contact
Constituent			
Chemicals	(a)	(b)	(b)
Antimony	0	5.7×10^{-2}	5.8×10^{-3}
Arsenic	0	4.6×10^{-4}	1.4×10^{-3}
Barium	1.3×10^{-3}	1.1×10^{-4}	6.7×10^{-5}
Beryllium	0	2.0×10^{-3}	1.3×10^{-5}
Cadmium	0	1.5×10^{-2}	4.8×10^{-4}
Chromium	0	7.2×10^{-3}	2.4×10^{-4}
Cobalt	1.1×10^{-1}	4.8×10^{-5}	1.4×10^{-5}
Copper	0	0	3.8×10^{-5}
Lead	0	0	0
Manganese	1.6×10^{-2}	1.7×10^{-2}	3.4×10^{-4}
Molybdenum	0	2.8×10^{-4}	7.1×10^{-5}
Nickel	0	9.0×10^{-5}	1.2×10^{-4}
Silver	0	0	1.5×10^{-4}
Uranium	0	4.4×10^{-2}	1.4×10^{-3}
Vanadium	0	7.1×10^{-4}	2.3×10^{-4}
Zinc	0	7.9×10^{-5}	1.3×10^{-5}
SUM	1.3×10^{-1}	1.4×10^{-1}	1.0×10^{-2}

Note: ^aHazard Indices calculated using intakes in Table E.III-4 and dose-response parameters in Tables E.4-2 and E.4-3.

^bHazard Indices calculated using intakes in Table E.III-7 and dose-response parameters in Tables E.4-2 and E.4-3.

TABLE E.IV-3

**ILCR FOR THE VISITOR, CURRENT LAND USE WITH ACCESS CONTROL
CURRENT SOURCE TERM**

Transfer Media>>>>>>>>	Air	Soil	Buried Pit Material
Exposure Route>>>>>>>>	Inhalation	External Radiation	External Radiation
Constituent			
Radionuclides	(a)	(b)	(c)
Cs-137 + 1 dtr	1.4×10^{-10}	1.9×10^{-5}	
Np-237 + 1 dtr	1.0×10^{-7}	2.0×10^{-6}	
Pu-238	1.1×10^{-7}	9.9×10^{-11}	
Pu-239/240	3.5×10^{-8}	3.3×10^{-11}	
Ra-226 & Pb-210 + 2 dtrs	5.4×10^{-6}	5.3×10^{-5}	
Ra-228 + 1 dtr	5.9×10^{-9}	3.2×10^{-5}	
Rn-222 + 4 dtrs	5.4×10^{-6}	NA ^e	
Sr-90 + 1 dtr	7.6×10^{-10}	0.0×10^0	
Tc-99	5.2×10^{-10}	4.8×10^{-11}	
Th-228 + 7 dtrs	3.1×10^{-6}	2.9×10^{-4}	
Th-230	1.5×10^{-5}	3.8×10^{-8}	
Th-232	8.4×10^{-7}	1.5×10^{-5}	
U-234	1.1×10^{-5}	1.7×10^{-8}	
U-235 + 1 dtr	1.2×10^{-6}	1.5×10^{-5}	
U-238 + 2 dtrs	9.1×10^{-5}	8.0×10^{-5}	
SUM	1.3×10^{-4}	8.3×10^{-4}	8.7×10^{-5}
Chemical	(d)		
Aroclor-1254	0	NA	NA
Arsenic	2.9×10^{-7}	NA	NA
Beryllium	2.7×10^{-8}	NA	NA
Cadmium	1.5×10^{-7}	NA	NA
Chromium	2.4×10^{-6}	NA	NA
Nickel	1.0×10^{-7}	NA	NA
SUM	3.0×10^{-6}		

Note:

- ^aRisks calculated using intakes in Table E.III-8 and dose-response parameters in Table E.4-1.
^bRisks calculated using intakes in Table E.III-11 and dose-response parameters in Table E.4-1.
^cRisk calculations for this exposure pathway are presented in Table E.IV-31.
^dRisks calculated using intakes in Table E.III-9 and dose-response parameters in Table E.4-2.
^eNA - Not applicable. Exposure pathway not evaluated for constituent.

4787

TABLE E.IV-4

HAZARD QUOTIENTS FOR THE VISITOR, CURRENT LAND USE
WITH ACCESS CONTROLS, CURRENT SOURCE TERM

Transfer Media>>>>>>		
Exposure Route>>>>>>	Air ^a	
Constituent	Inhalation	Hazard Index
Antimony	0	0
Arsenic	0	0
Barium	4.5×10^{-3}	4.5×10^{-3}
Beryllium	0	0
Cadmium	0	0
Chromium	0	0
Cobalt	3.9×10^{-1}	3.9×10^{-1}
Copper	0	0
Lead	0	0
Manganese	5.7×10^{-2}	5.7×10^{-2}
Molybdenum	0	0
Nickel	0	0
Silver	0	0
Uranium	0	0
Vanadium	0	0
Zinc	0	0
SUM	4.5×10^{-1}	4.5×10^{-1}

^aHazard Indices calculated using intakes in Table E.III-10 and dose-response parameters in Table E.4-2.

TABLE E.IV-6
HAZARD QUOTIENT FOR THE OFF-PROPERTY FARMER, ALL LAND USE
CURRENT SOURCE TERM

Transfer Media>>>>>>				
Exposure Route>>>>>>				
Air ^a				
Chemical	Inhalation	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk
Antimony	0	2.5×10^{-3}	6.0×10^{-4}	1.8×10^{-5}
Arsenic	0	4.0×10^{-4}	1.1×10^{-4}	1.3×10^{-5}
Barium	6.5×10^{-4}	4.4×10^{-5}	3.3×10^{-6}	3.1×10^{-5}
Beryllium	0	3.8×10^{-6}	7.4×10^{-7}	2.6×10^{-9}
Cadmium	0	1.3×10^{-3}	1.7×10^{-4}	1.2×10^{-3}
Chromium	0	9.4×10^{-5}	7.0×10^{-5}	7.8×10^{-5}
Cobalt	5.6×10^{-2}	5.2×10^{-6}	1.4×10^{-5}	5.7×10^{-6}
Copper	0	4.6×10^{-5}	4.9×10^{-5}	3.0×10^{-5}
Lead	0	0	0	0
Manganese	8.2×10^{-3}	1.8×10^{-4}	1.6×10^{-5}	5.5×10^{-5}
Molybdenum	0	3.0×10^{-5}	2.8×10^{-5}	2.8×10^{-5}
Nickel	0	1.7×10^{-4}	8.0×10^{-5}	5.5×10^{-5}
Silver	0	1.2×10^{-4}	7.8×10^{-5}	2.0×10^{-3}
Uranium	0	3.7×10^{-4}	4.0×10^{-6}	4.7×10^{-5}
Vanadium	0	7.4×10^{-5}	2.4×10^{-5}	7.9×10^{-7}
Zinc	0	4.7×10^{-5}	5.7×10^{-4}	2.2×10^{-4}
SUM	6.5×10^{-2}	5.4×10^{-3}	1.8×10^{-3}	3.8×10^{-3}

^aHazard Indices calculated using intakes in Table E.III-14 and dose-response parameters in Table E.4-2.

1042

TABLE E.IV-7
ILCR FOR THE OFF-PROPERTY USER OF MEAT AND DAIRY PRODUCTS, CURRENT LAND USE
CURRENT SOURCE TERM

Transfer Media>>>>>>>>>>	Soil		Surface Water	
Exposure Route>>>>>>>>>>	Ingestion of Meat	Ingestion of Milk	Ingestion of Meat	Ingestion of Milk
Constituent				
Radionuclides	(a)	(a)	(b)	(b)
Cs-137 + 1 dtr	4.6×10^{-6}	6.5×10^{-6}	3.3×10^{-6}	5.6×10^{-6}
Np-237 + 1 dtr	6.1×10^{-8}	2.2×10^{-8}	NA ^e	NA
Pu-238	4.0×10^{-11}	3.2×10^{-11}	NA	NA
Pu-239/240	1.4×10^{-11}	1.1×10^{-11}	NA	NA
Ra-226 + 8 dtrs	4.3×10^{-7}	3.1×10^{-6}	2.4×10^{-9}	2.2×10^{-8}
Ra-228 + 1 dtr	6.7×10^{-8}	4.9×10^{-7}	8.5×10^{-9}	7.3×10^{-8}
Sr-90 + 1 dtr	4.2×10^{-6}	8.4×10^{-5}	3.0×10^{-8}	7.1×10^{-7}
Tc-99	8.4×10^{-5}	4.0×10^{-4}	1.2×10^{-6}	6.9×10^{-6}
Th-228 + 7 dtrs	1.8×10^{-9}	6.0×10^{-9}	NA	NA
Th-230	5.8×10^{-9}	1.9×10^{-8}	1.2×10^{-12}	4.9×10^{-12}
Th-232	3.1×10^{-10}	1.0×10^{-9}	NA	NA
U-234	3.3×10^{-7}	3.9×10^{-6}	1.7×10^{-7}	2.4×10^{-6}
U-235 + 1 dtr	3.7×10^{-8}	4.4×10^{-7}	9.1×10^{-9}	1.3×10^{-7}
U-238 + 2 dtrs	2.3×10^{-6}	2.7×10^{-5}	6.2×10^{-7}	8.9×10^{-6}
SUM	9.5×10^{-5}	5.3×10^{-4}	5.4×10^{-6}	2.5×10^{-5}
Chemical	(c)	(c)	(d)	(d)
Aroclor-1254	6.7×10^{-4}	7.7×10^{-4}	NA	NA
Arsenic	5.4×10^{-6}	4.5×10^{-5}	5.8×10^{-6}	7.0×10^{-7}
Benzene	NA	NA	5.8×10^{-10}	7.3×10^{-10}
Beryllium	1.3×10^{-8}	3.5×10^{-6}	NA	NA
SUM	6.8×10^{-4}	8.2×10^{-4}	5.8×10^{-6}	7.0×10^{-7}

Note: ^aRisks calculated using intakes in Table E.III-16 and dose-response parameters in Table E.4-1.
^bRisks calculated using intakes in Table E.III-18 and dose-response parameters in Table E.4-1.
^cRisks calculated using intakes in Table E.III-16 and dose-response parameters in Table E.4-2.
^dRisks calculated using intakes in Table E.III-19 and dose-response parameters in Table E.4-2.
^eNA - Not applicable. Exposure pathway not evaluated for constituent.

TABLE E-IV.9
(Continued)

4787

Transfer Media>>>>>>>>	Air	Surface Soil/Exposed Pit Materials			Sediment			Buried Pit Materials
Exposure Route>>>>>>>>	Inhalation	Incidental Ingestion	Dermal Contact	External Exposure	External Exposure	Incidental Ingestion	Dermal Contact	External Exposure
Constituent								
Benzo(b)fluoranthene ⁱ	1.6×10^{-11}	9.9×10^{-10}	0	NA	NA	NA	NA	NA
Chrysene ⁱ	3.8×10^{-12}	2.4×10^{-11}	0	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene ⁱ	8.3×10^{-11}	5.2×10^{-10}	0	NA	NA	NA	NA	NA
Pentachlorophenol	0	3.1×10^{-10}	5.2×10^{-8}	NA	NA	NA	NA	NA
Tetrachloroethene	4.5×10^{-13}	2.0×10^{-10}	1.3×10^{-8}	NA	NA	NA	NA	NA
2,3,7,8-TCDF	0	6.0×10^{-9}	1.8×10^{-6}	NA	NA	NA	NA	NA
HpCDD	0	6.3×10^{-9}	1.9×10^{-7}	NA	NA	NA	NA	NA
HpCDF	0	2.7×10^{-9}	8.1×10^{-7}	NA	NA	NA	NA	NA
HxCDD	0	9.2×10^{-9}	2.8×10^{-6}	NA	NA	NA	NA	NA
HxCDF	0	8.1×10^{-9}	2.4×10^{-6}	NA	NA	NA	NA	NA
OCDD	0	3.8×10^{-9}	1.1×10^{-6}	NA	NA	NA	NA	NA
OCDF	0	2.2×10^{-10}	6.6×10^{-8}	NA	NA	NA	NA	NA
SUM (TEF for PAHs) ^b	1.2×10^{-4}	7.9×10^{-5}	6.6×10^{-5}			3.4×10^{-7}	1.8×10^{-5}	
SUM (BaP for PAHs) ^b	1.2×10^{-4}							

- Note: ^aRisks calculated using intakes in Table E.III-21 and dose-response parameters in Table E.4-1.
^bRisks calculated using intakes in Table E.III-24 and dose-response parameters in Table E.4-1.
^cRisks calculated using intakes in Table E.III-27 and dose-response parameters in Table E.4-1.
^dRisk calculations for this exposure pathway are presented in Table E.IV-32.
^eRisks calculated using intakes in Table E.III-22 and dose-response parameters in Table E.4-2.
^fRisks calculated using intakes in Table E.III-25 and dose-response parameters in Table E.4-2 and E.4-5.
^gRisks calculated using intakes in Table E.III-28 and dose-response parameters in Table E.4-2 and E.4-3.
^hNA - Not applicable. Exposure pathway not evaluated for constituent.
ⁱRisks calculated based on TEF approach for PAHs. Totals calculated for both TEF and BaP approach.

1046

TABLE E.IV-11

**ILCR FOR THE OFF-PROPERTY FARMER, ALL LAND USE WITHOUT ACCESS CONTROL
FUTURE SOURCE TERM**

Transfer Media>>>>>>>>	Air				Groundwater			
Exposure Route>>>>>>>>>	Inhalation	Ingestion Vegetables/Fruit	Ingestion of Meat	Ingestion of Milk	Ingestion Drinking Water	Ingestion Vegetables/Fruit	Ingestion of Meat	Ingestion of Milk
Constituent								
Radionuclides	(c)	(c)	(c)	(c)	(d)	(d)	(d)	(d)
Cs-137 + 1 dtr	4.2×10^{-10}	9.9×10^{-9}	1.8×10^{-8}	2.5×10^{-8}	NA	NA	NA	NA
Np-237 + 1 dtr	4.7×10^{-7}	4.8×10^{-8}	2.7×10^{-10}	9.9×10^{-11}	1.3×10^{-16}	4.2×10^{-17}	1.5×10^{-19}	5.5×10^{-20}
Pu-238	1.2×10^{-7}	8.7×10^{-9}	3.1×10^{-13}	2.5×10^{-13}	NA	NA	NA	NA
Pu-239/240	1.1×10^{-6}	8.5×10^{-8}	6.6×10^{-12}	5.3×10^{-12}	NA	NA	NA	NA
Ra-226 + Pb-210 + 2 dtrs	3.6×10^{-5}	6.6×10^{-6}	2.7×10^{-7}	2.0×10^{-6}	NA	NA	NA	NA
Rn-222 + 4 dtrs	3.6×10^{-5}	NA ^a	NA	NA	NA	NA	NA	NA
Sr-90 + 1 dtr	1.0×10^{-9}	9.5×10^{-9}	5.7×10^{-10}	1.1×10^{-8}	1.0×10^{-11}	4.3×10^{-12}	1.5×10^{-13}	3.2×10^{-12}
Tc-99	1.3×10^{-8}	2.6×10^{-8}	1.6×10^{-8}	7.3×10^{-8}	2.0×10^{-7}	6.2×10^{-8}	2.3×10^{-8}	1.1×10^{-7}
Th-230	5.0×10^{-4}	2.9×10^{-6}	3.5×10^{-9}	1.2×10^{-8}	NA	NA	NA	NA
Th-232 + 10 dtrs	8.0×10^{-5}	1.6×10^{-6}	1.9×10^{-9}	6.4×10^{-9}	NA	NA	NA	NA
U-234	6.9×10^{-5}	5.4×10^{-7}	6.0×10^{-9}	7.2×10^{-8}	4.8×10^{-5}	1.4×10^{-5}	1.1×10^{-7}	1.3×10^{-6}
U-235 + 1 dtr	6.4×10^{-6}	5.2×10^{-8}	5.8×10^{-10}	6.9×10^{-9}	1.1×10^{-5}	3.4×10^{-6}	2.4×10^{-8}	2.9×10^{-7}
U-238 + 2 dtrs	2.0×10^{-4}	1.3×10^{-6}	1.6×10^{-8}	1.9×10^{-7}	4.2×10^{-4}	1.3×10^{-4}	9.2×10^{-7}	1.1×10^{-5}
SUM	9.4×10^{-4}	1.3×10^{-5}	3.3×10^{-7}	2.3×10^{-6}	4.8×10^{-4}	1.5×10^{-4}	1.1×10^{-6}	1.3×10^{-5}
Chemicals	(e)	(e)	(e)	(e)	(f)	(f)	(f)	(f)
Arsenic	3.3×10^{-4}	5.9×10^{-4}	1.7×10^{-4}	2.0×10^{-5}	NA	NA	NA	NA
Beryllium	1.5×10^{-7}	1.1×10^{-6}	2.2×10^{-7}	7.7×10^{-7}	NA	NA	NA	NA
Cadmium	1.9×10^{-7}	0	0	0	NA	NA	NA	NA
Chromium	8.8×10^{-6}	0	0	0	NA	NA	NA	NA
Nickel	2.6×10^{-3}	0	0	0	NA	NA	NA	NA
Aroclor-1248	0	3.0×10^{-7}	2.5×10^{-7}	3.1×10^{-7}	NA	NA	NA	NA
Aroclor-1254	0.0×10^{-0}	2.7×10^{-7}	8.5×10^{-7}	7.0×10^{-7}	NA	NA	NA	NA
Benzo(a)anthracene ^a	3.2×10^{-10}	5.4×10^{-9}	3.0×10^{-9}	4.0×10^{-9}	NA	NA	NA	NA

TABLE E-IV.11
(Continued)

Transfer Media>>>>>>>>	Air				Groundwater			
Exposure Route>>>>>>>>	Inhalation	Ingestion Vegetables/Fruit	Ingestion of Meat	Ingestion of Milk	Ingestion Drinking Water	Ingestion Vegetables/Fruit	Ingestion of Meat	Ingestion of Milk
Constituent								
Benzo(a)pyrene	2.4×10^{-9}	4.2×10^{-8}	5.7×10^{-8}	7.2×10^{-8}	NA	NA	NA	NA
Benzo(b)fluoranthene	4.4×10^{-10}	6.6×10^{-9}	3.4×10^{-8}	4.3×10^{-8}	NA	NA	NA	NA
Benzo(g,h,i)perylene ^b	0	0	0	0	NA	NA	NA	NA
Chrysene ^b	1.0×10^{-11}	1.7×10^{-10}	9.6×10^{-11}	1.2×10^{-10}	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene ^b	2.4×10^{-10}	3.4×10^{-9}	2.2×10^{-7}	2.8×10^{-7}	NA	NA	NA	NA
Pentachlorophenol	0	2.2×10^{-9}	3.1×10^{-10}	3.8×10^{-10}	NA	NA	NA	NA
Tetrachloroethene	2.0×10^{-12}	7.8×10^{-10}	3.3×10^{-13}	4.2×10^{-13}	NA	NA	NA	NA
2,3,7,8-TCDF	0	3.9×10^{-8}	4.6×10^{-7}	9.0×10^{-7}	NA	NA	NA	NA
HpCDD	0	4.1×10^{-8}	4.8×10^{-7}	9.3×10^{-7}	NA	NA	NA	NA
HpCDF	0	1.4×10^{-8}	1.7×10^{-7}	3.2×10^{-7}	NA	NA	NA	NA
HxCDD	0	5.1×10^{-8}	6.0×10^{-7}	1.2×10^{-6}	NA	NA	NA	NA
HxCDF	0	5.3×10^{-8}	6.3×10^{-7}	3.2×10^{-6}	NA	NA	NA	NA
OCDD	0	2.6×10^{-8}	2.9×10^{-7}	5.6×10^{-7}	NA	NA	NA	NA
OCDF	0	1.5×10^{-9}	1.8×10^{-8}	3.3×10^{-8}	NA	NA	NA	NA
SUM (TEF for PAHs) ^b	2.9×10^{-3}	5.9×10^{-4}	1.7×10^{-4}	2.8×10^{-5}				
SUM (BaP for PAHs) ^b	2.9×10^{-3}	5.9×10^{-4}	1.7×10^{-4}	2.8×10^{-5}				

Note: ^aNA - Not applicable. Radon is a gas.

^bRisks calculated for PAHs based on TEF approach. Totals calculated for both TEF and BaP approach.

^cRisks calculated using intakes in Table E.III-30 and dose-response parameters in Table E.4-1.

^dRisks calculated using intakes in Table E.III-33 and dose-response parameters in Table E.4-1.

^eRisks calculated using intakes in Table E.III-31 and dose-response parameters in Table E.4-2 and E.4-4.

^fRisks calculated using intakes in Table E.III-34 and dose-response parameters in Table E.4-2.

TABLE EIV-13

**ILCR FOR THE GREAT MIAMI RIVER USER, CURRENT LAND USE
FUTURE CONDITIONS**

Radionuclide	Ingestion of Drinking Water	Ingestion of Vegetables and Fruit	Ingestion of Meat	Ingestion of Milk	Incidental Ingestion of Water	Ingestion of Fish	ILCR
Cs-137 + 1 dtr	3.8×10^{-12}	1.5×10^{-12}	1.6×10^{-12}	2.3×10^{-12}	5.0×10^{-15}	3.1×10^{-12}	1.2×10^{-11}
Np-237 + 1 dtr	5.0×10^{-10}	1.6×10^{-10}	5.6×10^{-13}	2.1×10^{-13}	6.4×10^{-13}	2.0×10^{-10}	8.6×10^{-10}
Pu-238	1.3×10^{-11}	3.9×10^{-12}	7.1×10^{-17}	5.9×10^{-17}	1.7×10^{-14}	7.0×10^{-10}	7.2×10^{-10}
Pu-239/240	3.4×10^{-12}	1.0×10^{-12}	2.0×10^{-17}	1.6×10^{-17}	4.4×10^{-15}	2.3×10^{-12}	6.7×10^{-12}
Sr-90 + 1 dtr	1.5×10^{-9}	6.2×10^{-10}	2.2×10^{-11}	2.2×10^{-11}	2.0×10^{-12}	1.0×10^{-9}	3.7×10^{-9}
Tc-99	1.3×10^{-8}	4.0×10^{-9}	1.6×10^{-9}	7.7×10^{-9}	1.7×10^{-11}	3.4×10^{-9}	2.9×10^{-8}
Th-230	4.2×10^{-11}	1.3×10^{-11}	3.5×10^{-15}	1.1×10^{-14}	5.5×10^{-14}	3.4×10^{-11}	8.9×10^{-11}
Th-232 + 10 dtrs	3.1×10^{-11}	9.5×10^{-12}	2.4×10^{-15}	8.4×10^{-15}	4.0×10^{-14}	2.5×10^{-11}	6.6×10^{-11}
U-234	2.0×10^{-8}	5.9×10^{-9}	4.3×10^{-11}	5.4×10^{-10}	2.5×10^{-11}	1.1×10^{-9}	2.7×10^{-8}
U-235 + 1 dtr	2.3×10^{-9}	6.8×10^{-10}	5.0×10^{-12}	6.3×10^{-11}	3.0×10^{-12}	1.2×10^{-10}	3.2×10^{-9}
U-238 + 2 dtrs	1.4×10^{-7}	4.3×10^{-8}	3.1×10^{-10}	3.9×10^{-9}	1.8×10^{-10}	7.6×10^{-9}	2.0×10^{-7}
SUM	1.8×10^{-7}	5.3×10^{-8}	2.0×10^{-9}	1.2×10^{-8}	2.3×10^{-10}	1.4×10^{-8}	2.5×10^{-7}

^aRisks calculated using intakes in Table E.III-35 and dose-response parameters in Table E.4-1.

TABLE E.IV-15

HAZARD QUOTIENTS FOR THE OFF-PROPERTY USER OF MEAT AND DAIRY PRODUCTS, CURRENT LAND USE, FUTURE SOURCE TERM

Transfer Media>>>>>>>	Soil		Surface Water	
Exposure Route>>>>>>>	Ingestion of Meat	Ingestion of Milk	Ingestion of Meat	Ingestion of Milk
Constituent				
Chemical	(b)	(b)	(c)	(c)
Antimony	3.0×10^{-1}	7.3×10^{-1}	1.6×10^{-2}	6.5×10^{-3}
Arsenic	1.0×10^{-2}	8.3×10^{-2}	1.2×10^{-2}	1.4×10^{-3}
Barium	9.3×10^{-3}	1.0×10^{-3}	9.6×10^{-4}	8.9×10^{-3}
Beryllium	6.0×10^{-7}	1.6×10^{-4}	NA	NA
Cadmium	6.7×10^{-1}	9.2×10^{-2}	NA	NA
Chromium	1.5×10^{-2}	1.4×10^{-2}	NA	NA
Cobalt	2.2×10^{-3}	5.3×10^{-3}	NA	NA
Copper	5.7×10^{-2}	9.7×10^{-2}	1.3×10^{-2}	7.6×10^{-3}
Cyanide	NA	NA	1.7×10^{-8}	2.4×10^{-8}
Lead	0	0	0	0
Manganese	7.9×10^{-2}	2.2×10^{-2}	NA	NA
Molybdenum	6.8×10^{-2}	6.8×10^{-2}	NA	NA
Nickel	2.1×10^{-2}	3.2×10^{-2}	8.0×10^{-3}	5.0×10^{-3}
Selenium	NA	NA	6.4×10^{-3}	7.0×10^{-3}
Silver	3.0×10^0	1.1×10^{-1}	7.0×10^{-3}	1.9×10^{-1}
Uranium	4.0×10^{-2}	3.3×10^{-3}	NA	NA
Vanadium	1.7×10^{-4}	5.6×10^{-3}	2.7×10^{-2}	8.9×10^{-4}
Zinc	4.7×10^{-1}	1.2×10^0	2.8×10^0	1.1×10^0
SUM	4.7×10^0	2.5×10^0	2.9×10^0	1.3×10^0

***NA - Not applicable.**

^bHazard indices calculated using intakes from Table E.III-38 and dose-response parameters from Table E.4-2.

^aHazard indices calculated using intakes from Table E.III-41 and dose-response parameters from Table E.4-2.

TABLE E.IV-17

HAZARD QUOTIENTS FOR THE ON-PROPERTY FARMER (RME), FUTURE LAND USE
FUTURE SOURCE TERM

Transfer Media>>>>>>>>																
Exposure Route>>>>>>>>>	Air				Soil*					Surface Water		Groundwater				
Constituent	Inhalation	Ingestion of Vegetable/Fruit	Ingestion of Meat	Ingestion of Milk	Incidental Ingestion	Dermal Contact	Ingestion of Vegetables/Fruit	Ingestion of Meat	Ingestion of Milk	Ingestion of Meat	Ingestion of Milk	Ingestion of Drinking Water	Dermal Contact While Bathing	Ingestion of Vegetables/Fruits	Ingestion of Meat	Ingestion of Milk
Chemical	(a)	(a)	(a)	(a)	(d)	(d)	(b)	(b)	(b)	(c)	(c)	(e)	(e)	(e)	(e)	(e)
Antimony	0	4.8×10^{-2}	1.2×10^{-2}	4.8×10^{-3}	2.0×10^{-1}	3.6×10^{-1}	1.5×10^1	7.3×10^{-1}	3.0×10^{-1}	1.6×10^{-2}	6.5×10^{-3}	1.2×10^1	2.0×10^{-1}	7.0×10^0	9.5×10^{-1}	3.8×10^{-1}
Arsenic	0	1.4×10^1	4.0×10^0	4.7×10^{-1}	2.5×10^1	7.4×10^{-1}	7.0×10^{-2}	8.3×10^{-2}	1.0×10^{-2}	1.2×10^{-2}	1.4×10^{-3}	5.3×10^1	1.4×10^{-1}	2.0×10^1	3.0×10^0	3.7×10^{-1}
Barium	1.0×10^0	7.0×10^{-2}	5.3×10^{-3}	4.9×10^{-2}	9.1×10^{-2}	2.8×10^{-2}	8.7×10^{-3}	1.0×10^{-3}	9.3×10^{-3}	9.6×10^{-4}	8.9×10^{-3}	2.5×10^{-1}	7.1×10^{-4}	2.4×10^{-1}	9.1×10^{-3}	8.6×10^{-2}
Beryllium	0	6.2×10^{-4}	1.2×10^{-4}	4.4×10^{-7}	1.7×10^{-3}	4.7×10^{-2}	1.7×10^{-4}	1.6×10^{-4}	6.0×10^{-7}	NA	NA	NA	NA	NA	NA	NA
Boron	3.5×10^{-4}	2.8×10^{-4}	6.0×10^{-6}	4.4×10^{-5}	5.9×10^{-4}	3.3×10^{-3}	NA ^f	NA	NA	NA	NA	9.4×10^{-3}	4.7×10^{-4}	2.8×10^{-3}	1.6×10^{-5}	1.4×10^{-4}
Cadmium	0	4.8×10^{-2}	6.5×10^{-3}	4.7×10^{-2}	2.1×10^{-4}	1.2×10^{-1}	6.2×10^{-1}	9.2×10^{-2}	6.7×10^{-1}	NA	NA	NA	NA	NA	NA	NA
Chromium	0	1.0×10^{-2}	7.8×10^{-3}	8.6×10^{-3}	2.1×10^{-2}	1.3×10^{-3}	9.2×10^{-3}	1.4×10^{-2}	1.5×10^{-2}	NA	NA	NA	NA	NA	NA	NA
Cobalt	1.8×10^0	1.6×10^{-4}	4.5×10^{-4}	1.8×10^{-4}	6.3×10^{-4}	4.1×10^{-4}	8.7×10^{-4}	5.3×10^{-3}	2.2×10^{-3}	NA	NA	NA	NA	NA	NA	NA
Copper	0	6.2×10^{-2}	6.5×10^{-2}	4.0×10^{-2}	5.3×10^{-2}	2.5×10^{-3}	8.1×10^{-2}	9.7×10^{-2}	5.7×10^{-2}	1.3×10^{-2}	7.6×10^{-3}	NA	NA	NA	NA	NA
Cyanide	0	1.9×10^{-5}	3.3×10^{-11}	4.1×10^{-11}	2.8×10^{-5}	0	NA	NA	NA	1.7×10^{-8}	2.4×10^{-8}	6.0×10^{-6}	0	2.7×10^{-6}	9.5×10^{-13}	1.4×10^{-12}
Lead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manganese	2.0×10^0	4.3×10^{-2}	3.5×10^{-3}	1.4×10^{-2}	5.3×10^{-2}	4.8×10^{-1}	1.5×10^{-1}	2.2×10^{-2}	7.9×10^{-2}	NA	NA	1.1×10^1	3.3×10^{-2}	2.9×10^{-1}	1.4×10^{-2}	5.0×10^{-2}
Mercury	5.0×10^{-4}	2.3×10^{-2}	6.0×10^{-2}	4.3×10^{-4}	4.3×10^{-3}	4.0×10^{-2}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Molybdenum	0	1.7×10^{-2}	1.6×10^{-2}	1.6×10^{-2}	3.3×10^{-2}	2.5×10^{-2}	3.6×10^{-2}	6.8×10^{-2}	6.8×10^{-2}	NA	NA	NA	NA	NA	NA	NA
Nickel	0	1.3×10^{-2}	6.0×10^{-3}	4.1×10^{-3}	8.3×10^{-3}	1.2×10^{-3}	6.5×10^{-2}	3.2×10^{-2}	2.1×10^{-2}	8.0×10^{-3}	5.0×10^{-3}	NA	NA	NA	NA	NA
Selenium	0	5.2×10^{-3}	6.6×10^{-3}	7.0×10^{-3}	3.6×10^{-3}	1.3×10^{-3}				6.4×10^{-3}	7.0×10^{-3}	NA	NA	NA	NA	NA
Silver	0	4.6×10^{-3}	3.2×10^{-3}	8.2×10^{-2}	7.3×10^{-3}	0	1.3×10^{-1}	1.1×10^{-1}	2.9×10^0	7.0×10^{-3}	1.9×10^{-1}	NA	NA	NA	NA	NA
Thallium	0	4.7×10^{-2}	3.3×10^{-1}	6.7×10^{-2}	1.6×10^{-1}	4.5×10^{-3}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tin	0	6.3×10^{-5}	6.2×10^{-4}	3.2×10^{-5}	1.2×10^{-4}	6.7×10^{-5}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Uranium	0	2.7×10^2	3.0×10^0	3.7×10^1	8.3×10^{-1}	4.5×10^0	5.0×10^{-2}	3.3×10^{-3}	4.0×10^{-2}	NA	NA	1.2×10^2	5.7×10^0	3.3×10^1	2.5×10^{-1}	3.1×10^0
Vanadium	0	1.7×10^{-1}	4.3×10^{-2}	1.7×10^{-3}	3.5×10^{-1}	1.9×10^{-1}	6.0×10^{-3}	5.6×10^{-3}	1.7×10^{-4}	2.8×10^{-2}	8.9×10^{-4}	NA	NA	NA	NA	NA
Zinc	0	2.6×10^{-2}	3.2×10^{-1}	1.3×10^{-1}	6.8×10^{-3}	8.3×10^{-4}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	7.8×10^{-4}	8.4×10^{-4}	1.0×10^{-1}	1.2×10^0	4.8×10^{-1}	2.8×10^0	1.1×10^0	NA	NA	NA	NA	NA
Tetrachlorophenol	NA	NA	NA	NA	1.5×10^{-5}	4.4×10^{-4}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SUM	4.8×10^0	2.8×10^3	7.9×10^0	3.8×10^1	2.7×10^1	6.5×10^0	1.6×10^1	2.5×10^0	4.7×10^0	2.9×10^0	1.3×10^0	2.0×10^2	6.1×10^0	6.1×10^1	4.2×10^0	4.0×10^0

*Hazard Indices calculated using intakes in Table E.III-44 and dose-response parameters in Table E.4-2.

*Hazard Indices calculated using intakes in Table E.III-47 and dose-response parameters in Table E.4-2.

*Hazard Indices calculated using intakes in Table E.III-50 and dose-response parameters in Table E.4-2.

*Hazard Indices calculated using intakes in Table E.III-53 and dose-response parameters in Tables E.4-2 and E.4-5.

*Hazard Indices calculated using intakes in Table E.III-56 and dose-response parameters in Tables E.4-2 and E.4-5.

NA - Not applicable

*Includes exposed pit material.

TABLE E.IV-18

**ILCR FOR THE ON-PROPERTY RESIDENT FARMER (CT), FUTURE LAND USE
FUTURE SOURCE TERM**

Transfer Media>>>>>>>>>>	Air				Soil						Surface Water		Groundwater						Buried Pit Material
Exposure Route>>>>>>>>>>	Inhalation	Ingestion of Vegetables/Fruit	Ingestion of Meat	Ingestion of Milk	Ingestion of Vegetables/Fruit	Ingestion of Meat	Ingestion of Milk	Incidental Ingestion	External Exposure	Dermal Control	Ingestion of Meat	Ingestion of Milk	Ingestion of Drinking Water	Ingestion of Vegetables/Fruit	Ingestion of Meat	Ingestion of Milk	Inhalation of VOCs	Dermal Contact	External Exposure
Constituent																			
Radionuclides	(c)	(c)	(c)	(c)	(d)	(d)	(d)	(e)	(e)		(f)	(f)	(g)	(g)	(g)	(g)			(h)
Ca-137 + 1 dtr	2.6 x 10 ⁻¹⁰	5.4 x 10 ⁻⁹	1.0 x 10 ⁻⁸	1.4 x 10 ⁻⁸	7.0 x 10 ⁻⁸	3.1 x 10 ⁻⁷	4.2 x 10 ⁻⁷	5.9 x 10 ⁻⁸	3.7 x 10 ⁻⁵	NA ^a	1.9 x 10 ⁻⁷	3.4 x 10 ⁻⁷	9.2 x 10 ⁻¹¹	2.6 x 10 ⁻¹¹	9.9 x 10 ⁻¹⁴	3.7 x 10 ⁻¹⁴	NA	NA	
Np-237 + 1 dtr	3.3 x 10 ⁻⁷	2.9 x 10 ⁻⁸	1.7 x 10 ⁻¹⁰	6.2 x 10 ⁻¹¹	9.0 x 10 ⁻⁸	4.2 x 10 ⁻⁹	1.5 x 10 ⁻⁹	2.9 x 10 ⁻⁷	5.2 x 10 ⁻⁶	NA	NA	NA	9.9 x 10 ⁻⁸	2.6 x 10 ⁻⁸	5.3 x 10 ⁻¹³	4.4 x 10 ⁻¹³	NA	NA	
Pu-238	9.8 x 10 ⁻⁸	6.0 x 10 ⁻⁹	2.3 x 10 ⁻¹³	1.8 x 10 ⁻¹³	3.1 x 10 ⁻¹⁰	2.6 x 10 ⁻¹²	2.2 x 10 ⁻¹²	6.2 x 10 ⁻⁸	7.0 x 10 ⁻¹¹	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Pu-239/240	9.8 x 10 ⁻⁷	6.6 x 10 ⁻⁸	5.3 x 10 ⁻¹²	4.3 x 10 ⁻¹²	1.1 x 10 ⁻¹⁰	9.7 x 10 ⁻¹³	7.8 x 10 ⁻¹³	2.8 x 10 ⁻⁷	2.9 x 10 ⁻¹⁰	NA	NA	NA	4.8 x 10 ⁻⁶	1.5 x 10 ⁻⁶	3.0 x 10 ⁻⁸	2.2 x 10 ⁻⁷	NA	NA	
Ra-226 & Pb-210 + 2 dtrs	3.2 x 10 ⁻⁵	5.1 x 10 ⁻⁶	2.2 x 10 ⁻⁷	1.6 x 10 ⁻⁶	9.4 x 10 ⁻⁸	2.8 x 10 ⁻⁸	2.0 x 10 ⁻⁷	1.7 x 10 ⁻⁵	1.2 x 10 ⁻³	NA	3.0 x 10 ⁻¹⁰	2.6 x 10 ⁻⁹	NA	NA	NA	NA	NA	NA	
Rn-222 + 4 dtr	3.2 x 10 ⁻⁵	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.8 x 10 ⁻¹⁰	2.2 x 10 ⁻¹⁰	7.9 x 10 ⁻¹²	1.6 x 10 ⁻¹⁰	NA	NA	
Sr-90 + 1 dtr	8.0 x 10 ⁻¹⁰	6.5 x 10 ⁻⁹	4.1 x 10 ⁻¹⁰	8.2 x 10 ⁻⁹	1.3 x 10 ⁻⁶	2.8 x 10 ⁻⁷	5.8 x 10 ⁻⁶	5.0 x 10 ⁻⁸	0	NA	1.7 x 10 ⁻⁹	4.0 x 10 ⁻⁸	7.2 x 10 ⁻⁸	2.1 x 10 ⁻⁸	8.7 x 10 ⁻⁹	4.2 x 10 ⁻⁸	NA	NA	
Tc-99	1.0 x 10 ⁻⁸	1.8 x 10 ⁻⁸	1.1 x 10 ⁻⁸	5.3 x 10 ⁻⁸	1.4 x 10 ⁻⁶	5.6 x 10 ⁻⁶	2.7 x 10 ⁻⁵	1.0 x 10 ⁻⁷	4.3 x 10 ⁻¹⁰	NA	1.0 x 10 ⁻⁷	5.9 x 10 ⁻⁷	4.6 x 10 ⁻⁸	1.3 x 10 ⁻⁸	3.4 x 10 ⁻¹²	1.2 x 10 ⁻¹¹	NA	NA	
Th-230	4.5 x 10 ⁻⁸	2.2 x 10 ⁻⁶	2.8 x 10 ⁻⁹	9.3 x 10 ⁻⁹	6.8 x 10 ⁻⁹	3.9 x 10 ⁻¹⁰	1.3 x 10 ⁻⁹	9.2 x 10 ⁻⁶	3.4 x 10 ⁻⁷	NA	9.2 x 10 ⁻¹⁴	3.6 x 10 ⁻¹³	NA	NA	NA	NA	NA	NA	
Th-232 + 10 dtrs	7.4 x 10 ⁻⁵	1.3 x 10 ⁻⁶	1.6 x 10 ⁻⁹	5.3 x 10 ⁻⁹	5.3 x 10 ⁻⁹	2.9 x 10 ⁻¹⁰	1.0 x 10 ⁻⁹	4.8 x 10 ⁻⁶	2.1 x 10 ⁻³	NA	NA	NA	4.8 x 10 ⁻⁵	1.3 x 10 ⁻⁵	1.0 x 10 ⁻⁷	1.3 x 10 ⁻⁶	NA	NA	
U-234	5.8 x 10 ⁻⁵	4.0 x 10 ⁻⁷	4.6 x 10 ⁻⁹	5.5 x 10 ⁻⁸	3.0 x 10 ⁻⁷	2.2 x 10 ⁻⁸	2.6 x 10 ⁻⁷	2.1 x 10 ⁻⁶	3.5 x 10 ⁻⁸	NA	1.4 x 10 ⁻⁸	2.1 x 10 ⁻⁷	1.1 x 10 ⁻⁵	3.0 x 10 ⁻⁶	2.2 x 10 ⁻⁸	2.9 x 10 ⁻⁷	NA	NA	
U-235 + 1 dtr	5.0 x 10 ⁻⁵	3.5 x 10 ⁻⁷	4.1 x 10 ⁻⁹	4.9 x 10 ⁻⁸	3.7 x 10 ⁻⁸	2.6 x 10 ⁻⁹	3.0 x 10 ⁻⁸	2.6 x 10 ⁻⁷	3.3 x 10 ⁻⁵	NA	8.0 x 10 ⁻¹⁰	1.1 x 10 ⁻⁸	4.2 x 10 ⁻⁸	1.1 x 10 ⁻⁸	8.7 x 10 ⁻⁷	1.1 x 10 ⁻⁵	NA	NA	
U-238 + 2 dtrs	1.6 x 10 ⁻⁸	9.6 x 10 ⁻⁷	1.1 x 10 ⁻⁸	1.3 x 10 ⁻⁷	2.2 x 10 ⁻⁶	1.5 x 10 ⁻⁷	1.8 x 10 ⁻⁶	7.8 x 10 ⁻⁶	8.9 x 10 ⁻⁵	NA	5.9 x 10 ⁻⁸	8.4 x 10 ⁻⁷	4.8 x 10 ⁻⁸	1.3 x 10 ⁻⁸	1.0 x 10 ⁻⁶	1.3 x 10 ⁻⁵	NA	NA	
SUM	8.7 x 10⁻⁸	1.0 x 10⁻⁸	2.7 x 10⁻⁷	1.9 x 10⁻⁶	5.5 x 10⁻⁶	6.4 x 10⁻⁶	3.6 x 10⁻⁵	4.2 x 10⁻⁵	3.5 x 10⁻³	NA	3.7 x 10⁻⁷	2.0 x 10⁻⁶	NA	NA	NA	NA	NA	NA	1.6 x 10⁻⁴
Chemical	(i)	(i)	(i)	(i)	(j)	(j)	(k)	(k)		(k)	(l)	(l)	(m)	(m)	(m)	(m)	(m)	(m)	
Arsenic	3.0 x 10 ⁻⁸	4.7 x 10 ⁻⁸	1.4 x 10 ⁻⁸	1.7 x 10 ⁻⁵	2.5 x 10 ⁻⁶	3.1 x 10 ⁻⁶	3.6 x 10 ⁻⁷	7.7 x 10 ⁻⁸	NA	5.9 x 10 ⁻⁶	4.3 x 10 ⁻⁷	5.2 x 10 ⁻⁸	2.0 x 10 ⁻³	6.8 x 10 ⁻⁴	1.1 x 10 ⁻⁴	1.3 x 10 ⁻³	0	5.1 x 10 ⁻⁶	NA
Benzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.2 x 10 ⁻¹¹	4.4 x 10 ⁻¹¹	NA	NA	NA	NA	NA	NA	NA
Beryllium	1.3 x 10 ⁻⁷	8.6 x 10 ⁻⁷	1.7 x 10 ⁻⁷	6.4 x 10 ⁻¹⁰	2.4 x 10 ⁻⁶	2.4 x 10 ⁻⁷	8.6 x 10 ⁻¹⁰	2.0 x 10 ⁻⁶	NA	1.5 x 10 ⁻⁵	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	1.7 x 10 ⁻⁷	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	7.8 x 10 ⁻⁶	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	2.3 x 10 ⁻⁷	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1248	0	2.4 x 10 ⁻⁷	2.1 x 10 ⁻⁷	2.6 x 10 ⁻⁷	NA	NA	NA	4.4 x 10 ⁻⁷	NA	1.2 x 10 ⁻⁴	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor-1254	0	2.2 x 10 ⁻⁷	6.9 x 10 ⁻⁷	5.9 x 10 ⁻⁷	8.5 x 10 ⁻⁶	5.3 x 10 ⁻⁵	4.5 x 10 ⁻⁵	1.5 x 10 ⁻⁶	NA	4.5 x 10 ⁻⁶	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene ^b	3.0 x 10 ⁻¹⁰	4.4 x 10 ⁻⁹	2.5 x 10 ⁻⁹	3.3 x 10 ⁻⁹	NA	NA	NA	7.7 x 10 ⁻⁹	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	2.2 x 10 ⁻⁸	3.3 x 10 ⁻⁷	4.7 x 10 ⁻⁷	6.0 x 10 ⁻⁷	NA	NA	NA	3.9 x 10 ⁻⁸	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE E.IV-19

HAZARD QUOTIENTS FOR THE ON-PROPERTY FARMER (CT), FUTURE LAND USE
FUTURE SOURCE TERM

4787

Transfer Media>>>>>>>>	Air				Soil*					Surface Water		Groundwater				
Exposure Route>>>>>>>>	Inhalation	Ingestion of Vegetable/Fruit	Ingestion of Meat	Ingestion of Milk	Incidental Ingestion	Dermal Contact	Ingestion of Vegetables/Fruit	Ingestion of Meat	Ingestion of Milk	Ingestion of Meat	Ingestion of Milk	Ingestion of Drinking Water	Dermal Contact While Bathing	Ingestion of Vegetables/Fruits	Ingestion of Meat	Ingestion of Milk
Constituent																
Chemical	(b)	(b)	(b)	(b)	(c)	(c)	(d)	(d)	(d)	(e)	(e)	(f)	(f)	(f)	(f)	(f)
Antimony	0	2.4×10^{-2}	5.8×10^{-3}	2.5×10^{-3}	8.5×10^{-2}	4.1×10^{-2}	7.3×10^{-1}	3.7×10^{-1}	1.5×10^{-1}	3.5×10^{-3}	8.5×10^{-3}	6.6×10^0	1.1×10^{-1}	3.5×10^0	5.0×10^{-1}	2.0×10^{-1}
Arsenic	0	7.0×10^0	2.0×10^0	2.4×10^{-1}	1.1×10^1	8.4×10^{-2}	3.7×10^{-1}	4.3×10^{-2}	5.3×10^{-3}	7.3×10^{-4}	6.0×10^{-3}	2.9×10^1	7.4×10^{-2}	1.0×10^1	1.6×10^0	1.9×10^{-1}
Barium	5.9×10^{-1}	3.4×10^{-2}	2.7×10^{-3}	2.6×10^{-2}	4.0×10^{-2}	3.2×10^{-3}	4.4×10^{-5}	5.3×10^{-6}	4.9×10^{-5}	4.7×10^{-3}	5.0×10^{-4}	1.4×10^{-1}	3.8×10^{-4}	1.2×10^{-1}	4.7×10^{-3}	4.4×10^{-2}
Beryllium	0	3.2×10^{-4}	6.2×10^{-5}	2.2×10^{-7}	7.3×10^{-4}	5.4×10^{-3}	8.6×10^{-5}	8.6×10^{-5}	3.0×10^{-7}	NA	NA	NA	NA	NA	NA	NA
Boron	2.0×10^{-4}	1.4×10^{-4}	3.1×10^{-6}	2.3×10^{-5}	2.6×10^{-4}	3.8×10^{-4}	NA*	NA	NA	NA	NA	5.1×10^{-3}	2.4×10^{-4}	1.4×10^{-3}	8.2×10^{-6}	7.3×10^{-5}
Cadmium	0	2.4×10^{-2}	3.4×10^{-3}	2.5×10^{-2}	9.6×10^{-3}	1.4×10^{-2}	3.1×10^{-1}	4.8×10^{-2}	3.5×10^{-1}	NA	NA	NA	NA	NA	NA	NA
Chromium	0	5.2×10^{-3}	4.2×10^{-3}	4.4×10^{-3}	9.3×10^{-3}	1.5×10^{-3}	4.6×10^{-3}	7.4×10^{-3}	8.0×10^{-3}	NA	NA	NA	NA	NA	NA	NA
Cobalt	1.1×10^0	8.5×10^{-5}	2.3×10^{-4}	9.5×10^{-3}	2.7×10^{-4}	4.4×10^{-5}	4.3×10^{-4}	2.8×10^{-3}	1.1×10^{-3}	NA	NA	NA	NA	NA	NA	NA
Copper	0	3.2×10^{-2}	4.9×10^{-6}	2.1×10^{-2}	2.4×10^{-2}	2.9×10^{-4}	4.1×10^{-2}	5.1×10^{-2}	3.0×10^{-2}	4.1×10^{-3}	6.8×10^{-3}	NA	NA	NA	NA	NA
Cyanide	0	9.5×10^{-6}	1.7×10^{-11}	2.2×10^{-11}	1.2×10^{-5}	0	NA	NA	NA	1.3×10^{-8}	9.0×10^{-9}	3.2×10^{-6}	0	1.4×10^{-6}	4.9×10^{-13}	7.0×10^{-13}
Lead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manganese	1.2×10^0	2.1×10^{-2}	2.0×10^{-3}	7.0×10^{-3}	2.3×10^{-2}	5.5×10^{-2}	7.1×10^{-2}	1.1×10^{-2}	3.9×10^{-2}	NA	NA	6.2×10^0	1.8×10^{-2}	1.5×10^{-1}	7.0×10^{-3}	2.6×10^{-2}
Mercury	2.9×10^{-4}	1.1×10^{-3}	3.2×10^{-2}	2.3×10^{-4}	1.9×10^{-3}	4.5×10^{-3}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Molybdenum	0	8.4×10^{-3}	8.2×10^{-3}	8.2×10^{-3}	1.5×10^{-2}	2.8×10^{-3}	1.9×10^{-2}	3.5×10^{-2}	3.5×10^{-2}	NA	NA	NA	NA	NA	NA	NA
Nickel	0	6.5×10^{-3}	3.2×10^{-3}	2.2×10^{-3}	3.7×10^{-3}	1.3×10^{-4}	3.2×10^{-2}	1.6×10^{-2}	1.1×10^{-2}	2.8×10^{-3}	4.1×10^{-3}	NA	NA	NA	NA	NA
Selenium	0	2.6×10^{-3}	3.4×10^{-3}	3.6×10^{-3}	1.6×10^{-3}	1.5×10^{-4}	NA	NA	NA	3.6×10^{-3}	3.4×10^{-3}	NA	NA	NA	NA	NA
Silver	0	2.4×10^{-3}	1.6×10^{-3}	4.4×10^{-2}	3.1×10^{-3}	0	6.4×10^{-2}	5.7×10^{-2}	1.6×10^0	9.8×10^{-2}	3.6×10^{-3}	NA	NA	NA	NA	NA
Thallium	0	2.3×10^{-2}	1.7×10^{-1}	3.5×10^{-2}	7.1×10^{-2}	5.1×10^{-3}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tin	0	3.2×10^{-5}	3.2×10^{-4}	1.6×10^{-5}	5.2×10^{-5}	7.7×10^{-6}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Uranium	0	1.4×10^2	1.6×10^0	1.9×10^1	3.6×10^{-1}	1.3×10^0	2.5×10^{-2}	1.7×10^{-3}	2.1×10^{-2}	NA	NA	6.3×10^1	3.1×10^0	1.7×10^1	1.3×10^{-1}	1.6×10^0
Vanadium	0	8.4×10^{-2}	2.9×10^{-2}	9.1×10^{-4}	1.5×10^{-1}	2.2×10^{-2}	3.0×10^{-3}	2.9×10^{-3}	9.3×10^{-5}	4.7×10^{-4}	1.4×10^{-2}	NA	NA	NA	NA	NA
Zinc	0	1.3×10^{-2}	1.7×10^{-1}	6.7×10^{-2}	3.3×10^{-4}	9.5×10^{-5}	5.0×10^{-2}	6.3×10^{-1}	2.5×10^{-1}	5.7×10^{-1}	1.5×10^0	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	6.7×10^{-6}	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethene	NA	NA	NA	NA	2.9×10^{-5}	9.4×10^{-5}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SUM	2.9×10^0	1.5×10^2	4.0×10^0	1.9×10^1	1.2×10^1	1.5×10^0	1.7×10^0	1.3×10^0	2.5×10^0	6.9×10^{-1}	1.5×10^0	1.0×10^2	3.4×10^0	3.1×10^1	2.2×10^0	2.1×10^0

*NA - Not applicable.
^bHazard indices calculated using intakes in Table E.III-64 and dose-response parameters in Table E.4-2.
^cHazard indices calculated using intakes in Table E.III-71 and dose-response parameters in Table E.4-2.
^dHazard indices calculated using intakes in Table E.III-65 and dose-response parameters in Table E.4-2.
^eHazard indices calculated using intakes in Table E.III-68 and dose-response parameters in Table E.4-2.
^fHazard indices calculated using intakes in Table E.III-74 and dose-response parameters in Table E.4-2.
^gIncluded exposed pit material.

TABLE E.IV-20
(CONTINUED)

Transfer Media>>>>>>>>	Air				Soil						Surface Water		Groundwater						Buried Pit Materials
Exposure Route>>>>>>>>>>	Inhalation	Ingestion of Vegetable/Fruit	Ingestion of Meat	Ingestion of Milk	Incidental Ingestion	External Exposure	Dermal Contact	Ingestion of Vegetables/Fruit	Ingestion of Meat	Ingestion of Milk	Ingestion of Meat	Ingestion of Milk	Ingestion of Drinking Water	Dermal Contact While Bathing	Inhalation of VOCs	Ingestion of Vegetables/Fruits	Ingestion of Meat	Ingestion of Milk	External Exposure
Constituent																			
Benzo(a)pyrene	2.5 x 10 ⁻⁴	1.7 x 10 ⁻⁶	1.1 x 10 ⁻⁶	1.1 x 10 ⁻⁵	3.1 x 10 ⁻⁷	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluoranthene ^b	4.5 x 10 ⁻¹¹	2.7 x 10 ⁻⁹	6.5 x 10 ⁻⁹	6.4 x 10 ⁻⁴	7.7 x 10 ⁻⁴	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene ^b	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene ^b	1.1 x 10 ⁻¹¹	6.7 x 10 ⁻¹⁰	1.8 x 10 ⁻¹⁰	1.8 x 10 ⁻⁹	1.8 x 10 ⁻⁹	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene ^b	2.4 x 10 ⁻¹⁰	1.4 x 10 ⁻⁴	4.2 x 10 ⁻⁷	1.5 x 10 ⁻⁶	4.0 x 10 ⁻⁴	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol	0	9.0 x 10 ⁻⁹	5.9 x 10 ⁻¹⁰	5.8 x 10 ⁻⁹	2.4 x 10 ⁻⁴	NA	2.4 x 10 ⁻⁷	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethene	1.1 x 10 ⁻¹²	2.1 x 10 ⁻⁹	4.1 x 10 ⁻¹³	4.1 x 10 ⁻¹²	1.7 x 10 ⁻⁴	NA	6.4 x 10 ⁻⁴	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2,3,7,8-TCDF	0	1.7 x 10 ⁻⁷	8.9 x 10 ⁻⁷	1.3 x 10 ⁻⁵	4.6 x 10 ⁻⁷	NA	8.4 x 10 ⁻⁶	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HpCDD	0	2.6 x 10 ⁻⁷	1.4 x 10 ⁻⁶	2.1 x 10 ⁻⁵	4.8 x 10 ⁻⁷	NA	8.7 x 10 ⁻⁶	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HpCDF	0	7.1 x 10 ⁻⁴	3.9 x 10 ⁻⁷	5.7 x 10 ⁻⁶	2.1 x 10 ⁻⁷	NA	3.6 x 10 ⁻⁶	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HxCDD	0	2.1 x 10 ⁻⁶	1.2 x 10 ⁻⁶	1.7 x 10 ⁻⁵	7.1 x 10 ⁻⁷	NA	1.3 x 10 ⁻⁵	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HxCDF	0	2.3 x 10 ⁻⁷	1.2 x 10 ⁻⁶	1.8 x 10 ⁻⁵	6.2 x 10 ⁻⁷	NA	1.1 x 10 ⁻⁵	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OCDD	0	1.0 x 10 ⁻⁷	5.7 x 10 ⁻⁷	8.4 x 10 ⁻⁶	2.9 x 10 ⁻⁷	NA	5.4 x 10 ⁻⁶	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OCDF	0	6.2 x 10 ⁻⁹	3.5 x 10 ⁻⁴	5.1 x 10 ⁻⁷	1.7 x 10 ⁻⁴	NA	3.0 x 10 ⁻⁷	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SUM (TEF for PAHs) ^b	3.6 x 10 ⁻⁴	2.5 x 10 ⁻³	3.3 x 10 ⁻⁴	4.1 x 10 ⁻⁴	6.1 x 10 ⁻³	NA	3.1 x 10 ⁻⁴	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SUM (BaP for PAHs) ^b	3.6 x 10 ⁻⁴	2.5 x 10 ⁻³	3.3 x 10 ⁻⁴	4.1 x 10 ⁻⁴	6.1 x 10 ⁻³	NA	3.1 x 10 ⁻⁴	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SUM	NA	NA	NA	NA	NA	NA	NA	5.8 x 10 ⁻⁴	1.3 x 10 ⁻⁴	7.8 x 10 ⁻⁴	9.9 x 10 ⁻⁷	9.2 x 10 ⁻⁷	8.1 X 10 ⁻³	1.4 X 10 ⁻⁶	0	3.6 X 10 ⁻³	2.5 X 10 ⁻⁴	2.3 X 10 ⁻⁴	NA

*NA - Not applicable.

^aRisks for PAHs calculated using TEF approach. Totals calculated based on both the TEF and BaP approach.^bRisks calculated using intakes from Table E.III-78 and dose-response parameters in Table E.4-1.^cRisks calculated using intakes from Table E.III-79 and dose-response parameters in Table E.4-2.^dRisks calculated using intakes from Table E.III-87 and dose-response parameters in Table E.4-1.^eRisks calculated using intakes from Table E.III-81 and dose-response parameters in Table E.4-2.^fRisks calculated using intakes from Table E.III-88 and dose-response parameters in Table E.4-2.^gRisks calculated using intakes from Table E.III-82 and dose-response parameters in Table E.4-2.^hRisks calculated using intakes from Table E.III-84 and dose-response parameters in Table E.4-1.ⁱRisks calculated using intakes from Table E.III-85 and dose-response parameters in Table E.4-2.^jRisks calculated using intakes from Table E.III-90 and dose-response parameters in Table E.4-1.^kRisks calculated using intakes from Table E.III-91 and dose-response parameters in Table E.4-2.^lRisks calculated for this exposure pathway are presented in Table E.IV-35.

TABLE E.IV-21

4787

HAZARD QUOTIENTS FOR THE ON-PROPERTY RESIDENT CHILD, FUTURE LAND USE
FUTURE SOURCE TERM

Transfer Media>>>>>>>>	Air				Soil					Surface Water		Groundwater					
Exposure Route>>>>>>>>	Inhalation	Ingestion of Vegetable/Fruit	Ingestion of Meat	Ingestion of Milk	Incidental Ingestion	Dermal Contact	Ingestion of Vegetables/Fruit	Ingestion of Meat	Ingestion of Milk	Ingestion of Meat	Ingestion of Milk	Ingestion of Drinking Water	Dermal Contact While Bathing	Inhalation of VOCs	Ingestion of Vegetables/Fruits	Ingestion of Meat	Ingestion of Milk
Constituent																	
Chemical	(b)	(b)	(b)	(b)	(c)	(c)	(d)	(d)	(d)	(e)	(e)	(f)	(f)	(f)	(f)	(f)	(f)
Antimony	0	1.8×10^{-1}	2.1×10^{-2}	6.5×10^{-2}	1.0×10^0	6.0×10^{-1}	5.8×10^0	1.3×10^0	4.0×10^0	3.0×10^{-2}	9.3×10^{-2}	3.9×10^1	4.5×10^{-1}	6.8×10^{-2}	2.8×10^1	5.3×10^0	NA
Arsenic	0	5.3×10^1	7.0×10^0	6.3×10^0	1.3×10^2	1.3×10^0	2.7×10^{-1}	1.5×10^{-1}	1.4×10^{-1}	2.1×10^{-2}	2.0×10^{-2}	1.7×10^2	3.1×10^{-1}	7.7×10^1	5.3×10^0	5.0×10^0	NA
Barium	1.0×10^0	2.7×10^{-1}	9.4×10^{-3}	6.9×10^{-1}	4.7×10^{-1}	4.7×10^{-2}	3.4×10^{-2}	1.9×10^{-3}	1.3×10^{-1}	1.7×10^{-3}	1.2×10^{-1}	8.3×10^{-1}	1.6×10^{-3}	9.3×10^{-1}	1.7×10^{-2}	1.2×10^0	NA
Beryllium	0	2.4×10^{-3}	2.2×10^{-4}	6.0×10^{-6}	8.7×10^{-3}	7.8×10^{-2}	6.6×10^{-4}	3.0×10^{-4}	8.2×10^{-6}	NA	NA	NA	NA	NA	NA	NA	NA
Boron	3.5×10^{-4}	1.1×10^{-3}	1.1×10^{-5}	6.2×10^{-4}	3.1×10^{-3}	5.6×10^{-3}	NA*	NA	NA	NA	NA	3.1×10^{-2}	1.0×10^{-3}	1.1×10^{-2}	2.9×10^{-5}	2.0×10^{-3}	NA
Cadmium	0	1.9×10^{-1}	1.2×10^{-2}	6.6×10^{-1}	1.1×10^{-1}	2.0×10^{-1}	2.4×10^0	1.7×10^{-1}	9.3×10^0	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	0	4.0×10^{-2}	1.4×10^{-3}	1.2×10^{-1}	1.1×10^{-1}	2.2×10^{-2}	3.6×10^{-2}	2.6×10^{-2}	2.2×10^{-1}	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	1.8×10^0	6.5×10^{-4}	8.2×10^{-4}	2.5×10^{-3}	3.3×10^{-3}	6.7×10^{-4}	3.3×10^{-2}	9.7×10^{-3}	3.0×10^{-2}	NA	NA	NA	NA	NA	NA	NA	NA
Copper	0	2.4×10^1	1.2×10^1	5.4×10^{-1}	2.7×10^{-1}	4.2×10^{-3}	3.2×10^{-1}	1.8×10^{-1}	8.1×10^{-1}	2.3×10^{-2}	1.1×10^{-1}	NA	NA	NA	NA	NA	NA
Cyanide	0	7.5×10^{-5}	6.0×10^{-11}	5.5×10^{-10}	1.4×10^{-4}	0	NA	NA	NA	3.1×10^{-8}	3.4×10^{-7}	1.9×10^{-5}	0	1.1×10^{-5}	1.7×10^{-12}	1.9×10^{-11}	NA
Lead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NA
Manganese	2.0×10^0	1.6×10^{-1}	6.9×10^{-3}	1.9×10^{-1}	2.7×10^{-1}	8.1×10^{-1}	5.7×10^{-1}	3.9×10^{-2}	1.1×10^0	NA	NA	3.7×10^1	4.9×10^{-4}	1.1×10^0	2.6×10^{-2}	7.0×10^{-1}	NA
Mercury	4.9×10^{-3}	8.7×10^{-3}	1.1×10^{-1}	6.0×10^{-3}	2.2×10^{-2}	6.7×10^{-2}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Molybdenum	0	6.4×10^{-2}	2.8×10^{-2}	2.2×10^{-1}	1.8×10^{-1}	4.2×10^{-2}	1.4×10^{-1}	1.2×10^{-1}	9.6×10^{-1}	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	0	5.0×10^{-2}	1.1×10^{-2}	6.0×10^{-2}	4.4×10^{-2}	2.0×10^{-3}	2.5×10^{-1}	5.5×10^{-2}	3.0×10^{-1}	1.4×10^{-2}	7.5×10^{-2}	NA	NA	NA	NA	NA	NA
Selenium	0	2.0×10^{-2}	1.2×10^{-2}	9.8×10^{-2}	1.9×10^{-2}	2.2×10^{-3}	NA	NA	NA	1.2×10^{-3}	9.8×10^{-2}	NA	NA	NA	NA	NA	NA
Silver	0	1.8×10^{-2}	5.6×10^{-3}	1.2×10^0	3.7×10^{-2}	0	5.0×10^{-1}	2.0×10^{-1}	4.2×10^1	1.3×10^{-2}	1.3×10^2	NA	NA	NA	NA	NA	NA
Thallium	0	1.8×10^{-1}	6.0×10^{-1}	9.3×10^{-1}	8.4×10^{-1}	7.7×10^{-2}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tin	0	2.5×10^4	1.1×10^{-3}	4.3×10^{-4}	6.2×10^{-4}	1.1×10^{-4}	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Uranium	0	1.1×10^3	5.3×10^0	5.0×10^2	4.2×10^0	7.3×10^0	1.9×10^{-1}	6.0×10^{-3}	2.7×10^{-1}	NA	NA	3.8×10^2	1.3×10^1	1.3×10^2	4.3×10^{-1}	4.3×10^1	NA
Vanadium	0	6.6×10^{-1}	9.9×10^{-2}	2.4×10^{-2}	1.8×10^0	3.1×10^{-1}	2.3×10^{-2}	1.0×10^{-2}	2.4×10^{-3}	5.1×10^{-2}	1.3×10^{-2}	NA	NA	NA	NA	NA	NA

TABLE E.IV-21
(CONTINUED)

487

Transfer Media>>>>>>>>>>	Air				Soil					Surface Water		Groundwater					
Exposure Route>>>>>>>>>>	Inhalation	Ingestion of Vegetable/Fruit	Ingestion of Meat	Ingestion of Milk	Incidental Ingestion	Dermal Contact	Ingestion of Vegetables/Fruit	Ingestion of Meat	Ingestion of Milk	Ingestion of Meat	Ingestion of Milk	Ingestion of Drinking Water	Dermal Contact While Bathing	Inhalation of VOCs	Ingestion of Vegetables/Fruits	Ingestion of Meat	Ingestion of Milk
Constituent																	
Zinc	0	1.0 x 10 ⁻¹	5.7 x 10 ⁻¹	1.8 x 10 ⁰	3.9 x 10 ⁻³	1.5 x 10 ⁻³	4.0 x 10 ⁻¹	2.2 x 10 ⁰	6.7 x 10 ⁰	5.0 x 10 ⁰	1.6 x 10 ¹	NA	NA	NA	NA	NA	NA
Pentachlorophenol	NA	NA	NA	NA	7.8 x 10 ⁻⁵	7.8 x 10 ⁻⁴	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tatrachloroethene	NA	NA	NA	NA	3.5 x 10 ⁻⁴	1.4 x 10 ⁻³	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SUM	4.8 x 10 ⁰	1.2 x 10 ³	1.3 x 10 ¹	5.1 x 10 ²	1.4 x 10 ²	1.1 x 10 ¹	1.1 x 10 ¹	4.5 x 10 ⁰	6.6 x 10 ¹	5.2 x 10 ⁰	1.5 x 10 ²	6.3 x 10 ²	1.4 x 10 ¹	2.1 x 10 ²	3.4 x 10 ¹	5.5 x 10 ¹	NA

NA - Not applicable.
^bHazard indices calculated using intakes from Table E.III-80 and dose-response parameters in Table E.4-2.
^cHazard indices calculated using intakes from Table E.III-86 and dose-response parameters in Table E.4-2.
^dHazard indices calculated using intakes from Table E.III-83 and dose-response parameters in Table E.4-2.
^eHazard indices calculated using intakes from Table E.III-89 and dose-response parameters in Table E.4-2.
^fHazard indices calculated using intakes from Table E.III-92 and dose-response parameters in Table E.4-2.

TABLE E.IV-22

**ILCR FOR THE ON-PROPERTY HOME BUILDER, FUTURE LAND USE,
FUTURE SOURCE TERM**

Transfer Media>>>>>>>>	Air	Soil*			Buried Pit Material
Exposure Route>>>>>>>>>>>>					
Constituent	Inhalation	Incidental Ingestion	External Exposure	Dermal Contact	External Exposure
Radionuclides	(c)	(d)	(d)		(e)
Cs-137 + dtr	6.3×10^{-12}	6.7×10^{-10}	8.6×10^{-8}	NA	
Np-237 + dtr	7.8×10^{-9}	2.6×10^{-9}	9.2×10^{-9}	NA	
Pu-238	2.3×10^{-9}	2.0×10^{-9}	4.6×10^{-13}	NA	
Pu-239/240	2.4×10^{-8}	7.1×10^{-10}	1.5×10^{-13}	NA	
Ra-226 & Pb-210 + 2 dtrs	7.7×10^{-7}	NA	NA	NA	
Rn-222 + 4 dtrs	7.7×10^{-7}	NA	NA	NA	
Sr-90 + 1 dtr	NA ^a	0	1.5×10^{-9}	NA	
Tc-99	2.4×10^{-10}	2.2×10^{-13}	2.7×10^{-10}	NA	
Th-230	1.1×10^{-5}	1.7×10^{-10}	2.6×10^{-7}	NA	
Th-232 + 10 dtrs	1.8×10^{-6}	1.6×10^{-6}	1.6×10^{-6}	NA	
U-234	1.4×10^{-6}	7.7×10^{-11}	2.2×10^{-8}	NA	
U-235 + 1 dtr	1.2×10^{-6}	7.0×10^{-8}	7.3×10^{-8}	NA	
U-238 + 2 dtrs	3.9×10^{-6}	3.7×10^{-7}	5.3×10^{-7}	NA	
SUM	2.1×10^{-5}	2.4×10^{-6}	2.6×10^{-6}	NA	2.78×10^{-6}
Chemical	(f)	(g)		(g)	
Aroclor-1242	NA	1.1×10^{-7}	NA	2.2×10^{-12}	NA
Aroclor-1248	NA	6.1×10^{-7}	NA	2.6×10^{-6}	NA
Aroclor-1254	NA	7.0×10^{-7}	NA	2.9×10^{-6}	NA
Arsenic	7.3×10^{-6}	1.2×10^{-7}	NA	1.4×10^{-9}	NA
Beryllium	3.1×10^{-9}	2.9×10^{-6}	NA	3.1×10^{-5}	NA
Cadmium	4.0×10^{-9}	NA	NA	NA	NA
Chromium	1.9×10^{-7}	NA	NA	NA	NA
Nickel	5.6×10^{-9}	NA	NA	NA	NA
Benzo(a)pyrene	5.3×10^{-10}	4.4×10^{-7}	NA	0	NA
Benzo(a)anthracene ^b	7.3×10^{-12}	6.9×10^{-8}	NA	0	NA

TABLE E.IV-22
(CONTINUED)

Transfer Media>>>>>>>>	Air	Soil*			Buried Pit Material
Exposure Route>>>>>>>>					
Constituent	Inhalation	Incidental Ingestion	External Exposure	Dermal Contact	External Exposure
Benzo(b)fluoranthene ^b	9.8×10^{-13}	6.3×10^{-8}	NA	0	NA
Benzo(k)fluoranthene	NA	1.9×10^{-8}	NA	0	NA
Chrysene ^b	2.3×10^{-13}	1.7×10^{-9}	NA	0	NA
Indeno(1,2,3-cd)pyrene ^b	5.1×10^{-12}	2.6×10^{-8}	NA	0	NA
Pentachlorophenol	0	2.1×10^{-8}	NA	9.8×10^{-8}	NA
Tetrachloroethene	2.8×10^{-14}	9.5×10^{-7}	NA	2.0×10^{-5}	NA
TCDD	NA	6.3×10^{-6}	NA	1.3×10^{-4}	NA
2,3,7,8-TCDF	0	6.3×10^{-8}	NA	1.3×10^{-6}	NA
HpCDD	0	1.1×10^{-7}	NA	2.3×10^{-6}	NA
HpCDF	0	4.7×10^{-7}	NA	9.6×10^{-6}	NA
HxCDD	0	2.0×10^{-6}	NA	3.9×10^{-5}	NA
HxCDF	0	1.3×10^{-8}	NA	2.7×10^{-7}	NA
OCDD	0	7.4×10^{-7}	NA	1.5×10^{-7}	NA
OCDF	0	1.4×10^{-7}	NA	2.9×10^{-6}	NA
1,2,3,7,8-PECDF	NA	1.1×10^{-5}	NA	2.4×10^{-4}	NA
2,3,4,7,8-PECDF	NA	2.6×10^{-5}	NA	4.8×10^{-4}	NA
SUM (TEF for PAHs) ^b	7.5×10^{-6}	2.8×10^{-5}	NA	4.8×10^{-4}	NA
SUM (BaP for PAHs) ^b	7.5×10^{-6}	NA	NA	NA	NA

* Included exposed pit material.

^a NA - Not applicable.^b Risks calculated based on TEF approach for PAHs. Totals calculated for both TEF and BaP approach.^c Risks calculated using intakes from Table E.III-96 and dose-response parameters from Table E-4.1.^d Risks calculated using intakes from Table E.III-99 and dose-response parameters from Table E-4.1.^e Risks calculated for this exposure pathway are provided in Table E.IV-36.^f Risks calculated using intakes from Table E.II-97 and dose-response parameters from Table E-4.2.^g Risks calculated using intakes from Table E.III-100 and dose-response parameters from Table E-4.2

TABLE E.IV-23

**HAZARD QUOTIENTS FOR THE ON-PROPERTY HOME BUILDER,
FUTURE LAND USE, FUTURE SOURCE TERM**

Transfer Media>>>>>>>	Air	Soil*	
Exposure Route>>>>>>>		Incidental Ingestion	Dermal Contact
Constituent	Inhalation		
Chemicals	(a)	(b)	(b)
Antimony	0	5.3×10^{-1}	3.7×10^{-1}
Arsenic	0	1.6×10^{-2}	1.7×10^{-4}
Barium	3.6×10^{-3}	6.1×10^{-2}	7.1×10^{-6}
Beryllium	0	9.4×10^{-3}	9.8×10^{-2}
Boron	4.4×10^{-5}	6.8×10^{-3}	1.4×10^{-2}
Cadmium	0	2.3×10^{-2}	4.8×10^{-2}
Chromium	0	4.9×10^{-2}	4.4×10^{-2}
Cobalt	2.3×10^{-1}	2.0×10^{-3}	4.8×10^{-4}
Copper	0	8.9×10^{-3}	1.5×10^{-4}
Cyanide	0	NA ^c	NA
Lead	0	0	0
Manganese	7.0×10^{-2}	3.1×10^{-2}	1.1×10^{-1}
Mercury	6.2×10^{-5}	NA	NA
Molybdenum	0	1.6×10^{-3}	3.6×10^{-3}
Nickel	0	8.0×10^{-3}	4.1×10^{-4}
Selenium	0	NA	NA
Silver	0	1.0×10^{-1}	0
Thallium	0	NA	NA
Tin	0	1.8×10^{-4}	3.7×10^{-5}
Uranium	0	2.9×10^1	6.1×10^1
Vanadium	0	5.3×10^{-2}	1.1×10^{-2}
Zinc	0	4.3×10^{-4}	1.9×10^{-4}
Tetrachloroethene	NA	2.8×10^{-4}	1.3×10^{-2}
Acenaphthene	NA	3.0×10^{-6}	2.2×10^{-4}
Anthracene	NA	8.3×10^{-7}	8.5×10^{-5}
Fluoranthene	NA	2.5×10^{-5}	1.9×10^{-3}
Fluorene	NA	5.3×10^{-6}	7.5×10^{-4}
Naphthalene	NA	2.5×10^{-5}	2.8×10^{-4}
Pyrene	NA	2.8×10^{-5}	2.0×10^{-3}
4-Nitrophenol	NA	3.5×10^{-5}	9.4×10^{-4}
Tributyl phosphate	NA	1.3×10^{-2}	4.7×10^{-2}
SUM	3.0×10^{-1}	3.0×10^1	6.2×10^1

*Hazard Indices calculated using intakes in Table E.III-101 and dose-response parameters in Tables E.4-2 and E.4-5.

^bHazard Indices calculated using intakes in Table E.III-98 and dose-response parameters in Tables E.4-2.

^cNA - Not applicable.

*Includes exposed pit materials.

TABLE E.IV-24

ILCR FOR THE ON-PROPERTY ADULT (RME) PERCHED GROUNDWATER USER,
FUTURE LAND USE, FUTURE SOURCE TERM

Transfer Media>>>>>	
Exposure Route?>>>>>	Perched Groundwater
Constituent	Ingestion
Radionuclide^c	
Cs-137 + 1 dtr	1.2×10^{-4}
Np-237 + 1 dtr	8.1×10^{-5}
Pu-238	5.3×10^{-6}
Pu-239/240	5.8×10^{-7}
Ra-226 + 8 dtrs	2.7×10^{-3}
Sr-90 + 1 dtr	7.2×10^{-5}
Tc-99	1.7×10^{-4}
Th-230	2.0×10^{-7}
Th-232 + 10 dtrs	4.3×10^{-7}
U-234	1.2×10^{-1}
U-235 + 1 dtr	2.2×10^{-2}
U-238 + 2 dtrs	5.9×10^{-1}
SUM	7.3×10^{-1} $(5.2 \times 10^{-1})^b$
Chemical	
Aroclor-1248	1.1×10^{-2}
Aroclor-1254	2.1×10^{-2}
Arsenic	3.1×10^{-2}
Beryllium	2.4×10^{-3}
Benzo(a)anthracene ^c	1.2×10^{-3}
Benzo(a)pyrene	8.0×10^{-3}
Benzo(b)fluoranthene ^c	9.9×10^{-4}
Benzo(k)fluoranthene ^c	4.2×10^{-4}
Chrysene ^c	3.5×10^{-5}
Dibenzo(a,h)anthracene ^c	2.2×10^{-3}
Indeno(1,2,3-cd)pyrene ^c	2.2×10^{-3}

TABLE E.IV-24
(Continued)

4787

Transfer Media>>>>>>	Perched Groundwater
Exposure Route?>>>>>	
Constituent	Ingestion
TCDF	2.3×10^{-3}
HpCDD	3.9×10^{-5}
HpCDF	8.3×10^{-5}
HxCDD	3.2×10^{-4}
HxCDF	5.0×10^{-4}
OCDD	7.4×10^{-6}
OCDF	4.5×10^{-6}
1,2,3,7,8-PeCDF	2.0×10^{-4}
2,3,4,7,8-PeCDF	2.3×10^{-3}
Pentachlorophenol	6.6×10^{-4}
Tetrachloroethene	2.0×10^{-4}
Vinyl chloride	5.1×10^{-2}
SUM (TEF for PAHs)^c	1.4×10^{-1}
SUM (BaP for PAHs)^c	1.8×10^{-1}
	$(1.3 \times 10^{-1})^b$

^aRisks calculated using intakes in Table E.III-58 and dose-response parameters in Table E.4-2.

^bCalculated using the one-hit model.

^cRisks calculated based on TEF approach for PAHs. Totals calculated for both TEF and BaP approach.

^dRisks calculated using intakes in Table E.III-57 and dose-response parameters in Table E.4-1.

4787

TABLE E.IV-25

**HAZARD QUOTIENTS FOR THE ON-PROPERTY ADULT (RME) PERCHED
GROUNDWATER USER, FUTURE LAND USE, FUTURE SOURCE TERM**

Transfer Media>>>>>>	Perched Groundwater
Exposure Route>>>>>>	
Constituent	Drinking Water
Chemical	
Antimony	6.5×10^1
Arsenic	5.8×10^1
Barium	7.7×10^{-1}
Beryllium	1.1×10^{-1}
Boron	8.9×10^{-1}
Cadmium	6.4×10^0
Chromium	7.1×10^{-1}
Cobalt	1.6×10^{-1}
Copper	7.0×10^{-1}
Cyanide	5.0×10^0
Lead	0
Manganese	1.3×10^1
Mercury	2.0×10^0
Molybdenum	6.4×10^2
Nickel	2.9×10^0
Selenium	2.1×10^{-2}
Silver	3.7×10^{-1}
Thallium	3.5×10^2
Tin	3.8×10^{-1}
Uranium	4.6×10^3
Vanadium	5.6×10^0
Zinc	1.6×10^{-1}
Acenaphthene	1.8×10^{-2}
Anthracene	3.7×10^{-3}
Fluoranthene	2.8×10^{-2}
Fluorene	2.8×10^{-2}
Naphthalene	1.1×10^{-2}
Phenanthrene	0
Pyrene	3.7×10^{-2}
4-Nitrophenol	4.5×10^{-3}
Pentachlorophenol	1.8×10^{-1}
Tetrachloroethene	3.8×10^{-1}
SUM	5.7×10^3

*Hazard Indices calculated using intakes in Table E.III-59 and dose-parameters in Table E.4-2.

1069

TABLE E.IV-26

4787

ILCR FOR THE ON-PROPERTY ADULT (CT) PERCHED GROUNDWATER USER,
FUTURE LAND USE, FUTURE CONDITIONS

Transfer Media>>>>>>	Perched Groundwater
Exposure Route>>>>>>	
Constituent	Drinking Water
Radionuclide	
Cs-137 + 1 dtr	8.7×10^{-6}
Np-237 + 1 dtr	5.7×10^{-6}
Pu-238	3.7×10^{-7}
Ra-226 + 8 dtrs	2.0×10^{-4}
Pu-239/240	3.9×10^{-8}
Sr-90 + 1 dtr	5.0×10^{-6}
Tc-99	1.2×10^{-5}
Th-230	1.3×10^{-8}
Th-232 + 10 dtrs	3.1×10^{-8}
U-234	8.3×10^{-3}
U-235 + 1 dtr	1.6×10^{-3}
U-238 + 2 dtrs	4.2×10^{-2}
SUM	5.2×10^{-2} $(5.1 \times 10^{-2})^b$
Chemical	
Arsenic	2.2×10^{-3}
Beryllium	1.7×10^{-5}
Tetrachloroethene	1.4×10^{-3}
Vinyl Chloride	3.6×10^{-3}
Pentachlorophenol	4.7×10^{-5}
Aroclor-1248	7.5×10^{-4}
Aroclor-1254	1.5×10^{-3}
Benzo(a)anthracene ^b	8.6×10^{-5}
Benzo(a)pyrene	5.7×10^{-4}
Benzo(b)fluoranthene ^b	7.0×10^{-5}
Benzo(k)fluoranthene ^b	3.0×10^{-5}
Chrysene ^b	2.4×10^{-6}
Dibenzo(a,h)anthracene ^b	1.6×10^{-4}
Indeno(1,2,3-cd)pyrene ^b	1.6×10^{-4}
2,3,7,8-TCDF	1.5×10^{-4}
HpCDD	2.7×10^{-6}
HpCDF	5.9×10^{-6}
HxCDD	2.3×10^{-5}
HxCDF	3.5×10^{-5}
OCDD	5.3×10^{-7}
OCDF	3.2×10^{-7}
1,2,3,7,8-PeCDF	1.4×10^{-5}
2,3,4,7,8-PeCDF	1.6×10^{-4}
SUM (TEF for PAHs)^b	9.8×10^{-3}
SUM (BaP for PAHs)^b	1.2×10^{-2}

^aRisks calculated using intakes in Table E.III-75 and dose-response parameters in Table E.4-1.^bCalculated using the one-hit model.

1070

4787 TABLE E.IV-27

**HAZARD QUOTIENTS FOR THE ON-PROPERTY ADULT (CT) PERCHED
GROUNDWATER USER, FUTURE LAND USE, FUTURE SOURCE TERM**

Transfer Media>>>>>>>	
Exposure Route>>>>>>>	Perched Groundwater
Constituent	Drinking Water
Chemical	
Antimony	3.5×10^1
Arsenic	3.2×10^1
Barium	4.2×10^{-1}
Beryllium	6.2×10^{-2}
Boron	4.9×10^{-1}
Cadmium	3.6×10^2
Chromium	3.9×10^{-1}
Cobalt	8.5×10^{-2}
Copper	3.8×10^{-1}
Cyanide	1.1×10^{-3}
Lead	0
Manganese	7.2×10^0
Mercury	1.1×10^0
Molybdenum	3.4×10^2
Nickel	1.6×10^0
Selenium	1.1×10^{-2}
Silver	2.0×10^{-1}
Thallium	1.8×10^2
Tin	2.2×10^{-1}
Uranium	2.5×10^3
Vanadium	3.1×10^0
Zinc	9.0×10^{-2}
Acenaphthene	1.0×10^{-2}
Anthracene	2.0×10^{-3}
Fluoranthene	1.5×10^{-2}
Fluorene	1.5×10^{-2}
Naphthalene	6.0×10^{-3}
Phenanthrene	0
Pyrene	2.0×10^{-2}
4-Nitrophenol	2.5×10^{-3}
Pentachlorophenol	1.0×10^{-1}
Tetrachloroethene	2.1×10^{-1}
SUM	3.1×10^3

*Hazard Indices calculated using intakes in Table E.III-77 and dose-parameters in Table E.4-2.

TABLE E.IV-28

4782

ILCR FOR THE ON-PROPERTY CHILD PERCHED GROUNDWATER USER,
FUTURE LAND USE, FUTURE CONDITIONS

Transfer Media>>>>>>	Perched Groundwater
Exposure Route>>>>>>	
Constituent	Drinking Water
Radionuclides	
Cs-137 + 1 dtr	7.3×10^{-6}
Np-237 + 1 dtr	4.8×10^{-6}
Pu-238	3.1×10^{-6}
Pu-239/240	3.5×10^{-8}
Ra-226 + 8 dtrs	1.6×10^{-4}
Sr-90 + 1 dtr	4.3×10^{-6}
Tc-99	1.0×10^{-5}
Th-230	1.1×10^{-8}
Th-232 + 10 dtrs	2.6×10^{-8}
U-234	7.0×10^{-3}
U-235 + 1 dtr	1.3×10^{-3}
U-238 + dtrs	3.6×10^{-2}
SUM	4.4×10^{-2} (4.3×10^{-2}) ^b
Chemical	
Aroclor - 1248	2.9×10^{-3}
Aroclor - 1254	5.9×10^{-3}
Arsenic	8.6×10^{-3}
Beryllium	6.9×10^{-4}
Benzo(a)anthracene ^c	3.4×10^{-4}
Benzo(a)pyrene	2.3×10^{-3}
Benzo(b)fluoranthene ^c	2.8×10^{-4}
Benzo(k)fluoranthene ^c	1.2×10^{-4}
Chrysene ^c	9.9×10^{-6}
Dibenzo(a,h)anthracene ^c	6.2×10^{-4}
Indeno(1,2,3,-cd)pyrene ^c	6.2×10^{-4}
2,3,7,8-TCDF	6.2×10^{-4}
HpCDD	1.1×10^{-5}
HpCDF	2.3×10^{-5}
HxCDD	8.7×10^{-5}
HxCDF	1.4×10^{-4}
OCDD	2.1×10^{-6}
OCDF	1.3×10^{-6}
1,2,3,7,8-PeCDF	5.8×10^{-5}
2,3,4,7,8-PeCDF	6.3×10^{-4}
Pentachlorophenol	1.8×10^{-4}
Tetrachloroethene	5.6×10^{-5}
Vinyl Chloride	1.5×10^{-2}
SUM (TEF for PAHs)^c	3.9×10^{-2}
SUM (BaP for PAHs)^c	4.8×10^{-2}

^aRisks calculated using intakes in Table E.III-94 and dose-parameters in Table E.4-2.^bCalculated using the one-hit model.^cRisks calculated for PAHs based on TEF approach total are calculated for both TEF and BaP approach.

4787

TABLE E.IV-29

**HAZARD QUOTIENTS FOR THE ON-PROPERTY CHILD PERCHED GROUNDWATER
USER, FUTURE LAND USE, FUTURE SOURCE TERM**

Transfer Media>>>>>>	
Exposure Route>>>>>>	Perched Groundwater
Constituent	Drinking Water
Chemical	
Antimony	2.2×10^2
Arsenic	1.9×10^2
Barium	2.5×10^0
Beryllium	3.6×10^{-1}
Boron	2.9×10^0
Cadmium	2.2×10^0
Chromium	2.3×10^0
Cobalt	5.0×10^{-1}
Copper	2.3×10^0
Cyanide	1.6×10^1
Lead	0
Manganese	4.4×10^1
Mercury	6.7×10^0
Molybdenum	5.0×10^{-2}
Nickel	9.5×10^0
Selenium	6.8×10^{-2}
Silver	1.2×10^0
Thallium	1.1×10^3
Tin	1.2×10^0
Uranium	1.5×10^4
Vanadium	1.9×10^1
Zinc	5.3×10^{-1}
Acenaphthene	6.0×10^{-2}
Anthracene	1.2×10^{-2}
Fluoranthene	9.0×10^{-2}
Fluorene	9.0×10^{-2}
Naphthalene	3.5×10^{-2}
Phenanthrene	0
Pyrene	1.2×10^0
4-Nitrophenol	1.5×10^{-2}
Pentachlorophenol	6.0×10^{-1}
Tetrachloroethene	1.3×10^0
SUM	1.7×10^4

*Hazard Indices calculated using intakes in Table E-III-95 and dose-response parameters in Table E-4.2.

1073

TABLE E.IV-30

4787

**RISKS FROM PENETRATING RADIATION^a
CURRENT CONDITIONS - BURIED PIT MATERIAL
TRESPASSING CHILD UNDER CURRENT LAND USE WITHOUT ACCESS CONTROLS**

Source	Surface Area (m ²)	Fraction of Time Spent Exposed Over Source ^b (unitless)	Dose Rate ^c (mRem/hr)	Total Exposure ^d (mRem/Life)	Risk ^d (risk/Life)
Pit 1	7680	0.051	0.024	3.0	1.9 x 10 ⁻⁶
Pit 2	4170	0.028	0.057	3.9	2.4 x 10 ⁻⁶
Pit 3	22400	0.148	0.044	16	1.0 x 10 ⁻⁵
Pit 4	7790	0.052	7.8 x 10 ⁻⁶	0.0010	6.3 x 10 ⁻¹⁰
Pit 5	NA ^f	NA ^f	NA ^f	NA ^f	NA ^f
Pit 6	NA ^f	NA ^f	NA ^f	NA ^f	NA ^f
Burn Pit	2020	0.013	0.14	4.7	2.9 x 10 ⁻⁶
Clearwell	NA ^f	NA ^f	NA ^f	NA ^f	NA ^f
Total Risk					1.7 x 10 ⁻⁵

^aThese risks are in addition to risks associated with penetrating radiation from surface soils.

^bCalculated as the source area divided by the total area available to a roaming trespassing child. (Area of OU1 = 151000 m²)

^cResults of Microshield calculations (Table E.3-8)

^dThe product of the dose rate (mRem/hr), the exposure time (4 hr/d), the fraction of time exposed (unitless), the exposure frequency (52 d/y), and the exposure duration (12 years).

^eThe product of the total exposure (mRem/Life) and the dose-to-risk conversion factor from the WPA (6.2 E-7 risk/mRem) (DOE, 1993a).

^fSource covered by deep standing water. Exposures to an individual standing on the shoreline are negligible.

1074

4787 TABLE E.IV-31
RISKS FROM PENETRATING RADIATION^a
CURRENT CONDITIONS - BURIED PIT MATERIAL
VISITOR UNDER CURRENT LAND USE WITH ACCESS CONTROLS

Source	Surface Area (m ²)	Fraction of Time Spent Exposed Over Source ^b (unitless)	Dose Rate ^c (mRem/hr)	Total Exposure ^d (mRem/Life)	Risk ^d (risk/Life)
Pit 1	7680	0.051	0.024	15	9.5×10^{-6}
Pit 2	4170	0.028	0.057	20	1.2×10^{-5}
Pit 3	22400	0.148	0.044	82	5.1×10^{-5}
Pit 4	7790	0.052	7.8×10^{-6}	0.0051	3.1×10^{-9}
Pit 5	NA ^f	NA ^f	NA ^f	NA ^f	NA ^f
Pit 6	NA ^f	NA ^f	NA ^f	NA ^f	NA ^f
Burn Pit	2020	0.013	0.14	23	1.5×10^{-5}
Clearwell	NA ^f	NA ^f	NA ^f	NA ^f	NA ^f
				Total Risk	8.7×10^{-5}

^aThese risks are in addition to risks associated with penetrating radiation from surface soils.

^bCalculated as the source area divided by the total area available to a roaming visitor. (Area of OU1 = 151000 m²)

^cResults of Microshield calculations (Table E.3-6)

^dThe product of the dose rate (mRem/hr), the exposure time (2 hr/d), the fraction of time exposed (unitless), the exposure frequency (250 d/y), and the exposure duration (25 years).

^eThe product of the total exposure (mRem/Life) and the dose-to-risk conversion factor from the WPA (6.2 E-7 risk/mRem) (DOE, 1993a)

^fSource covered by deep standing water. Exposures to an individual standing on the shoreline are negligible.

TABLE E.IV-32

4787

**RISKS FROM PENETRATING RADIATION^a
FUTURE CONDITIONS - BURIED PIT MATERIAL
TRESPASSING CHILD UNDER CURRENT LAND USE WITHOUT ACCESS CONTROLS**

Source	Surface Area (m ²)	Fraction of Time Spent Exposed Over Source ^b (unitless)	Dose Rate ^c (mRem/hr)	Total Exposure ^d (mRem/Life)	Risk ^d (Risk/Life)
Pit 1	7680	0.051	0.024	3.0	1.9 x 10 ⁻⁶
Pit 2	4170	0.028	0.057	3.9	2.4 x 10 ⁻⁶
Pit 3	NA ^f	NA ^f	NA ^f	NA ^f	NA ^f
Pit 4	7790	0.052	7.8 x 10 ⁻⁶	0.0010	6.3 x 10 ⁻¹⁰
Pit 5	NA ^g	NA ^g	NA ^g	NA ^g	NA ^g
Pit 6	NA ^g	NA ^g	NA ^g	NA ^g	NA ^g
Burn Pit	2020	0.013	0.14	4.7	2.9 x 10 ⁻⁶
Clearwell	NA ^g	NA ^g	NA ^g	NA ^g	NA ^g

Total Risk 7.2 x 10⁻⁶

^aThese risks are in addition to risks associated with penetrating radiation from surface soils.

^bCalculated as the source area divided by the total area available to a roaming trespasser. (Area of OU1 = 151000 m²)

^cResults of Microshield calculations (Table E.3-8).

^dThe product of the dose rate (mrem/hr), the exposure time (4 hr/d), the fraction of time exposed (unitless), the exposure frequency (52 d/y), and the exposure duration (12 years).

^eThe product of the total exposure (mrem/Life) and the dose to risk conversion factor from the WPA (6.2 E-7 risk/mrem) (DOE, 1993a).

^fSource has no cover and exposed material is assessed as surface soil.

^gSource covered by deep standing water. Exposures to an individual standing on the shoreline are negligible.

1076

TABLE E.IV-33

**RISKS FROM PENETRATING RADIATION^a
FUTURE CONDITIONS - BURIED PIT MATERIAL
ON-PROPERTY RME ADULT UNDER FUTURE LAND USE**

Source	Surface Area (m ²)	Fraction of Time Spent Exposed Over Source ^b (unitless)	Total Time Spent Exposed to Source ^c (hr/Lifetime)	Dose Rate ^d (mRem/hr)	Total Exposure ^e (mRem/Life)	Risk ^f (risk/Life)
Pit 1	7680	0.051	31010	0.024	744	4.6 x 10 ⁻⁴
Pit 2	4170	0.028	16838	0.057	960	6.0 x 10 ⁻⁴
Pit 3	NA ^g	NA ^g	NA ^g	NA ^g	NA ^g	NA ^g
Pit 4	7790	0.052	453159	7.8 x 10 ⁻⁶	3.6	2.2 x 10 ⁻⁶
Pit 5	NA ^h	NA ^h	NA ^h	NA ^h	NA ^h	NA ^h
Pit 6	NA ^h	NA ^h	NA ^h	NA ^h	NA ^h	NA ^h
Burn Pit	2020	0.013	1338	0.14	187	1.2 x 10 ⁻⁴
Clearwell	NA ^h	NA ^h	NA ^h	NA ^h	NA ^h	NA ^h
Total Risk						1.2 x 10 ⁻³

^aThese risks are in addition to risks associated with penetrating radiation from surface soils.

^bCalculated as the source area divided by the total area available to an on-property adult. (Area of OU1 = 151,000 m²).

^cAssumes RME spends 350 d/y (8400 hr/y) on-property for 70 years. 2000 hr/y of this time is spent outdoors, and the remaining 6400 hr/y is spent indoors. The RME farms Pits 1 and 2 for 800 hr/y over 50 years. Thus the RME spends 448,200 hrs indoors in structures build on Pit 4; 40,000 hrs on Pits 1 and 2; and the remaining 100,000 hrs roaming randomly over the operable unit. Shielding by the home is not considered in this calculation.

^dResults of Microshield calculations (Table E.3-8).

^eThe product of the dose rate (mRem/hr), and the total time exposed (hr/lifetime).

^fThe product of the total exposure (mRem/Life) and the dose to risk conversion factor from the WPA (6.2 E-7 risk/mRem) (DOE, 1993a).

^gCover over source is gone. Exposed waste treated as surface soil (Table E.IV-54).

^hSource covered by deep standing water. Exposures to an individual standing on the shoreline are negligible.

TABLE E.IV-34

**RISKS FROM PENETRATING RADIATION
FUTURE CONDITIONS - BURIED PIT MATERIAL
ON-PROPERTY CT ADULT UNDER FUTURE LAND USE^a**

Source	Surface Area (m ²)	Fraction of Time Spent Exposed Over Source ^b (unitless)	Total Time Spent Exposed to Source ^c (hr/Lifetime)	Dose Rate ^d (mRem/hr)	Total Exposure ^e (mRem/Life)	Risk ^f (risk/Life)
Pit 1	7680	0.051	4758	0.024	114	7.1×10^{-5}
Pit 2	4170	0.028	2583	0.057	147	9.1×10^{-5}
Pit 3	NA ^g	NA ^g	NA ^g	NA ^g	NA ^g	NA ^g
Pit 4	7790	0.052	45093	7.8×10^{-6}	0.4	2.2×10^{-7}
Pit 5	NA ^h	NA ^h	NA ^h	NA ^h	NA ^h	NA ^h
Pit 6	NA ^h	NA ^h	NA ^h	NA ^h	NA ^h	NA ^h
Burn Pit	2020	0.013	24	0.14	3	2.1×10^{-6}
Clearwell	NA ^h	NA ^h	NA ^h	NA ^h	NA ^h	NA ^h
Total Risk						1.6×10^{-4}

^aThese risks are in addition to risks associated with penetrating radiation from surface soils.

^bCalculated as the source area divided by the total area available to an on-property adult. (Area of OU1 = 151,000 m²).

^cAssumes the CT spends 250 d/y (6000 hr/y) for 9 years on-property. 1,000 hr/y of this time is spent outdoors and the remaining 5000 hr/y is spent indoors. The RME farms Pits 1 and 2 for 800 hr/y over 9 years. Thus the CT spends 45,000 hrs indoors in structures build on Pit 4; 7,200 hrs on Pits 1 and 2; and the remaining 1,800 hrs roaming randomly over the operable unit. Shielding by the home is not considered in this calculation.

^dResults of Microshield calculations (Table E.3-8)

^eThe product of the dose rate (mrem/hr), the exposure time (4 hr/d), the fraction of time exposed (unitless), the exposure frequency (52 d/y), and the exposure duration (12 years).

^fThe product of the total exposure (mrem/Life) and the dose to risk conversion factor from the WPA (6.2 E-7 risk/mrem) (DOE, 1993a)

^gCover over source is gone. Exposed waste treated as surface soil (Table E.IV-74)

^hSource covered by deep standing water. Exposures to an individual standing on the shoreline are negligible.

1078

TABLE E.IV-35

4707 RISKS FROM PENETRATING RADIATION
FUTURE CONDITIONS - BURIED PIT MATERIAL
ON-PROPERTY CHILD UNDER FUTURE LAND USE^a

Source	Surface Area (m ²)	Fraction of Time Spent Exposed Over Source ^b (unitless)	Total Time Spent Exposed to Source ^c (hr/Lifetime)	Dose Rate ^d (mrem/hr)	Total Exposure ^e (mRem/Life)	Risk ^f (risk/Life)
Pit 4	7790	1.0	50400	7.8×10^{-6}	0.4	2.4×10^{-7}
Total Risk						2.4×10^{-7}

^aThese risks are in addition to risks associated with penetrating radiation from surface soils.

^bThe mobility of a child aged 1-6 is assumed to be restricted to vicinity of the home on Pit 4

^cAssumes the child spends 24 hr/d, 350 d/y for 6 years in or near the home

^dResults of Microshield calculations (Table E.3-8)

^eThe product of the total time exposed (hr/Life) and the dose rate (mRem/hr)

^fThe product of the total exposure (mRem/Life) and the dose to risk conversion factor from the WPA (6.2 E-07 risk/mRem) (DOE, 1993a)

TABLE E.IV-36

**RISKS FROM PENETRATING RADIATION
FUTURE CONDITIONS - BURIED PIT MATERIAL
ON-PROPERTY HOME BUILDER UNDER FUTURE LAND USE^A**

4787

Source	Surface Area (m ²)	Fraction of Time Spent Exposed Over Source ^b (unitless)	Total Time Spent Exposed to Source ^c (hr/Lifetime)	Dose Rate ^d (mRem/hr)	Total Exposure ^e (mRem/Life)	Risk ^f (risk/Life)
Pit 4	7790	1.000	548000	7.8×10^{-6}	4.3	2.7×10^{-6}

Total Risk 2.7×10^{-6}

^aThese risks are in addition to risks associated with penetrating radiation from surface soils.

^bAssumes the home is built on Pit 4, as described in the conceptual model.

^cAssumes the home builder builds a house in 500 hours (NRC 1984)

^dResults of Microshield calculations (Table E.3-6)

^eThe product of the total time exposed (hr/Life) and the doserate (mRem/hr)

^fThe product of the total exposure (mrem/Life) and the dose to risk conversion factor from the WPA (6.2 E-7 risk/mRem) (DOE, 1993a)

1080